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July 6, 1933

Engineering News-Record

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Sacramento Water Filtration Plant Sets New Standards in Pre-Treatment

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Demoistured Air Aids Madden Dam Cement

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Difficult Caisson Sinking for Vancouver Water Tunnel

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Highway Vehicle Operating Economies

Second Article of a Series on How the Highway Pays

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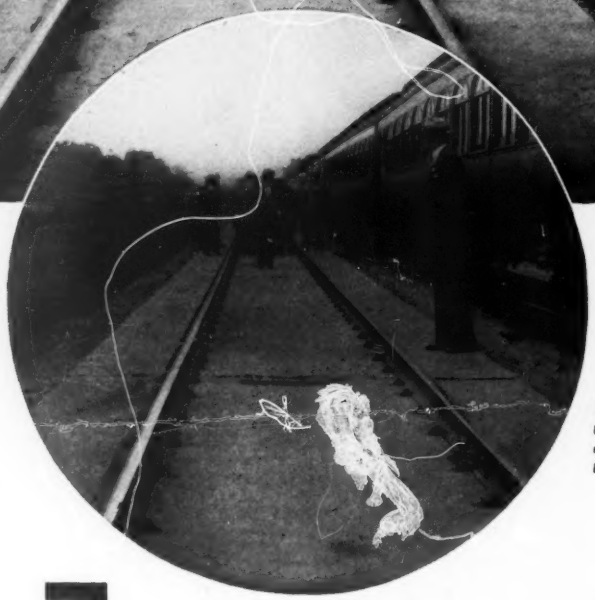

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Sacramento Sets New Standards in Pre-Treatment

Shallow settling basins designed on basis of area—New plant is completely mechanized, including continuous grit and sludge removal, forced ventilation of aeration field and spirovortex chemical mixing—New structures raised above ground for flood protection

By Harry N. Jenks

Consulting Sanitary Engineer, Visiting Professor of Sanitary and Hydraulic Engineering, University of North Carolina, Chapel Hill, N. C.

DURING the early part of this year the city of Sacramento, Calif., placed in operation at its filtration plant a new pre-treatment works having a capacity of 64 m.g.d. The historical background and engineering development of the municipal waterworks at Sacramento, culminating in the present improvements, were described in *Engineering News-Record*, April 28, 1932, p. 626. It will serve as an introduction to this discussion of the unusual pre-treatment installation.

The chief objective of the new construction is to augment the capacity of the entire filtration plant, to enable the old sedimentation basins to be converted into filtered-water storage reservoirs, and to facilitate the application of auxiliary treatment processes to cope with special problems of operation, particularly those of taste and odor removal during the summer months.

Several unusual features have been embodied in the new plant. Earthquake-resistant construction is used, the shallow basins resting on pile clusters entirely above ground. Sedimentation is in two stages. Putrescible sludge or sediment is removed in the preliminary circular settlers. Inclined plates in shallow rectangular sedimentation tanks augment the area factor twice. Aeration is effected by spray nozzles as well as riffled inclined cascades. An elaborate ventilating system washes away the odors as soon as they are released by the aerators. Circular mixing tanks have large low-head pumps in the center to effect gentle stirring to agglomerate the floc. Large inlets and outlets produce low velocities and thus prevent floc dispersion. Fine sediment, containing little organic matter, from the final settlers is returned to the raw water to expedite floc formation.

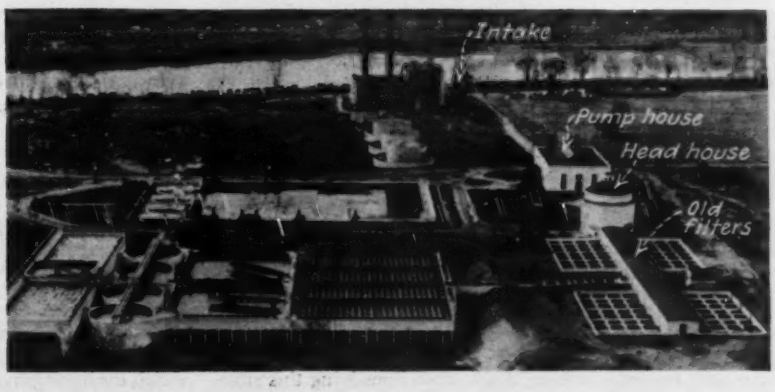


Fig. 1—Enlarged Sacramento filter plant with pre-treatment works in foreground delivering water to existing filters at right. Plant is elevated and outside the levee.

Basic design considerations

The new plant occupies a 2¼-acre site adjacent to the original sedimentation basins. The general arrangement of the pre-treatment works was conditioned by the requirements of the site and the need for the elimination of certain functional shortcomings of the conventional type of plant in relation to the filtration of the local river-water supply.

Structural Aspects—The new plant was built on

1,900 composite piles driven to firm bearing 50 ft. below grade. Individual pile clusters, surmounted by caps, furnish support for the columns on which the plant superstructures rest. The general top elevation of the basin walls is 24 ft. above the ground level, corresponding with the required flow line through the filtration plant. As noted in Fig. 1, the placing of the new plant on columns results in a unique form of construction, where it is possible to walk underneath every unit except the mixing tanks, the bottoms of which are at ground level. All piping and conduits are also above ground.

The elevated basins introduced important structural problems, such as provision for expansion and contraction and resistance to earthquake shock. A further structural consideration was the total bearing power of the soil, regardless of the load-carrying ability of the piling itself. The original plant was surrounded by a sand fill furnishing spaces for roadways and landscaping, but the surcharging of the area around the new plant by such grading operations was not permitted. In respect to the foundation loads, the shallow-basin design that was adopted became doubly advantageous because of the decrease in total weight of water and a similar lessening of the total weight of structure per unit area.

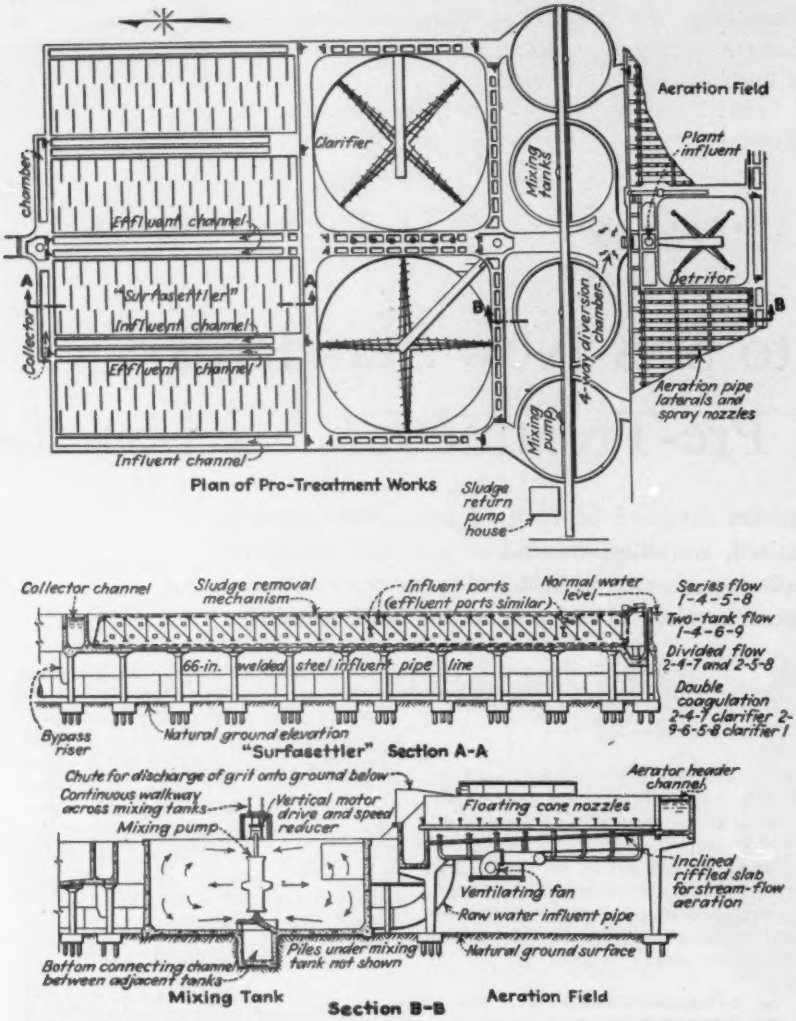


Fig. 2—Pre-treatment at Sacramento comprises grit remover, aeration mixing and two types of settling. Cross-flow between inclined baffles is used in final settling basins caller "surfasettlers." Mixing tanks utilize large low-head pump of new type. Aeration field has riffled floor slab and floating cone nozzles.

Functional Requirements—A functional need that developed during the operation of the original plant was the prompt removal of the sediment from the sedimentation basins. The high organic content of the sediment during the summer months caused decomposition to occur with evolution of gases of putrefaction in a manner similar to that in a sewage-sludge digestion tank. The overlying clarified water became contaminated with objectionable odors and tastes, thus undoing the beneficial effects of the rapid-sand filtration process as a whole. Aside from remedying this situation, the continuous removal of the sediment inherently permitted the construction of shallow basins, wherein an insignificant amount of volumetric space is required for sediment storage.

No thought was entertained of providing continuous sediment removal for the sake of avoiding the cleaning of basins periodically by hand, since the volume of sediment with the relatively low turbidities encountered in Sacramento River water is reasonably small. The use of continuous sediment-removal equipment, therefore, represents a change indicated by experience and constitutes the only complete departure from the functional theory on which the original Sacramento plant was designed.

Although it is true that, in their physical embodiment, all the remaining functions of the pre-treatment process appear in greatly modified and in some respects unique form, yet these changes in effect simply take advantage of the numerous improvements in the art and practice of water treatment of the past nine years, since the Sacramento filtration plant was first placed in service.

Shallow Basins—While engaged in 1921 in the operation of an experimental small-scale filter plant, under the direction of Prof. Charles Gilman Hyde, chief consulting engineer, and W. F. Langelier, consulting bacteriologist of the original filtration project, the writer studied systematically the influence of numerous factors on the sedimentation of coagulated Sacramento River water. It was noted that practically complete settlement of the alum floc occurred at velocities substantially greater than those ordinarily regarded as subsiding velocities. This fact was attributed largely to the extraordinary settleability imparted to the floc by reason of the prolonged mixing and agglomeration period of coagulation, a conclusion amply verified by subsequent practice.

The writer was further impressed with the relative importance of the superficial area of the basin on rates of sedimentation and recorded his observations and conclusions in an informal report at the time. Almost exactly ten years later the peculiar requirements of construction of the new pre-treatment works, coupled with the great improvements in continuous sediment-removal equipment, presented the opportunity for the practical application of the theory of sedimentation-basin design on the area basis advocated in 1921.

New Experiments—In order to define accurately the governing elements of design for full-scale units, a 150,000-gal.-per-day experimental field plant, comprising mechanical mixing followed by sedimentation and filtration, was built near the existing equalizing basin, from which raw water was delivered by gravity to the experimental installation. The studies centered on the phenomena of sedimentation in a unit 15 ft. long by 7 ft. wide by 5 ft. water depth, for which the descriptive word "surfasettler"

was coined to designate the fact that the design of such a unit is based on the surface area onto which the floc may settle.

To carry out the purpose of determining the effect of varying the area factor, Ralph Stevenson, who was superintendent of the Sacramento filtration works at the time and conducted the field tests, proposed the use of inclined plates positioned in the tank so as to intercept the floc in its travel downward toward the bottom. The use of such plates was in conformity with the fact that clarification of a supernatant liquid takes place more rapidly in an inclined tube or similar vessel than in a vertical one, a phenomenon observed by the engineers of the Sanitary District of Chicago in sludge-settlement investigations reported in 1921. (*Engineering News-Record*, May 12, 1921, p. 815.)

As a result of the Sacramento experimental work, it was shown definitely that, with due allowance for sufficient area of sedimentation coupled with a sufficiently prolonged time of mixing and agglomeration prior to settling, both the depth and detention period of the basin could be substantially diminished. The efficiency of sedimentation under different operating conditions was judged by the behavior of the experimental rapid-sand filter, particularly in regard to the length of filter runs. Throughout the period of tests the results were correlated with the corresponding behavior and length of runs of the filters of the full-scale plant. The conclusion was reached that it would be proper to design the new pre-treatment works basins for a depth not to exceed 8 ft., and a detention period of one hour, the basins having a composite area factor of 1.0 sq.ft. per gallon per minute flow.

The new pre-treatment works

Influent Line—The influent line of the new pre-treatment works is a 66-in. welded-steel pipe laid above ground underneath the major axis of the plant, as indicated in Fig. 2. A master 66x36-in. venturi meter serves to indicate the raw-water flow electrically at three control points of the filter plant. Bypass risers from the influent line at appropriate intervals permit raw water to be delivered into any of the major units of the pre-treatment works independently of the operation of the preceding units. Due to the length and size of the pipe line, time is had for the satisfactory mixing of ammonia and/or chlorine injected into the line between the pumping station and the grit basin.

Grit Removal—Grit removal, which is required seasonally during flood stages of the Sacramento River, is accomplished in a 50-ft. square grit remover or detritor, having a capacity of 64 cu.yd. of grit per day. The grit is dumped "overboard" by the cleaning mechanism, the material falling down a chute to the ground below the grit-basin

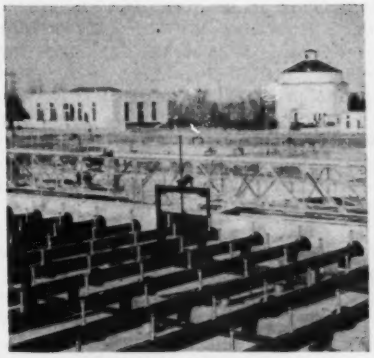


Fig. 3—Aeration tank with floating cone nozzles and cascade floor. Note the ventilating-duct mushroom outlets below laterals.

Fig. 4—Ventilating system under the aeration fields. Fans deliver 20,000 cu.ft. of free air per minute to each field through risers extending through the inclined floor slab.

structure. The water flows from the grit remover through the aeration system by gravity. The depth of flow increases automatically with increased pumpage, the water level corresponding to the head required by the aerator nozzles. A detritor bypass gate is provided, leading directly to the collector channel ahead of the mixing tanks.

Aeration System—Two aeration fields, each 60x120 ft. in plan, contain 576 Sacramento-type floating-cone nozzles, operating at a maximum head of 5½ ft. when discharging 80 g.p.m. per nozzle. The sprays are spaced at 5-ft. centers, on 12-in. welded-steel-pipe laterals 60 ft.

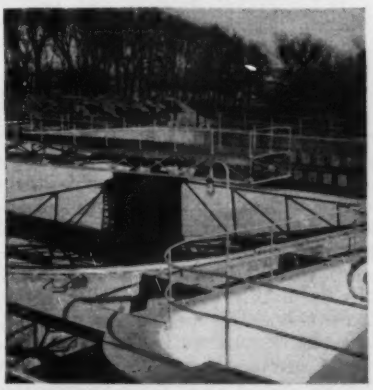


Fig. 5—Inlet and outlet ports to clarifiers are baffled as shown on the back wall.

long. The lateral system and nozzle risers are laid out according to principles governing the design of perforated-pipe underdrain systems for filters, thus insuring uniformity of discharge with constant size and spacing of pipes and nozzles.

Supplementary aeration is obtained by the flow of the water over a riffled inclined slab forming the floors of the aerator inclosures. It is also possible to depend solely on this streamflow aeration by opening the bypass gates in the aerator header channel and allowing the entire flow to pass over the corrugated floor, thus avoiding the pumping head required by the nozzles, although the latter is low in any event.

As an additional aid in thoroughly aerating the water and dissipating the odors imparted to the air surrounding the sprays, provision was made for introducing fresh air from underneath the structure through mushroom outlets that distribute a maximum of 20,000 cu.ft. of free air per minute over each field, thus insuring a positive displacement of the air underneath the ceiling of the spray once every minute. This form of ventilation corresponds to what one might term an air wash at the rate of 33-in. vertical rise per minute. It is believed that this air washing will effectively prevent the re-absorption of odors from the air into the water. Fig. 3 shows the aerator spray nozzles and streamflow riffles, and Fig. 4 shows the ventilating system underneath the structure.

Mechanical Mixers—The installation of mechanical mixing tanks is notable for both their size and the manner in which a prolonged and thorough mixing of the water is secured. Four circular tanks are employed, each tank being 56 ft. in diameter, with a normal water depth of 21 ft. The aggregate mixing period at 64-m.g.d. rate of flow is 36 min. The mixing velocities may be adjusted to include true mixing and agglomeration of the floc, thus relieving the settling basins of any function as coagulation units. As may be noted from the design of the aeration system, an initial rapid mixing may be secured either through the spray nozzles or over the riffled floor slab. Thus the whole range of velocities for complete coagulation and agglomeration of the floc is obtainable under controlled conditions.

Six different sequences of operation of the mixing tanks, including double coagulation with intermediate sedimentation in one of the clarifiers, are available in the new pre-treatment works. To accomplish these different routings of the flow, a four-way gate chamber on a large scale was designed.

All channels communicating with the tanks are designed for good hydraulic conditions, with easy transitions and curves to minimize the loss of head. A total of 6-in. loss of head was allowed for operation of the four tanks in series.

In view of the unprecedented size of the tanks, so far as mechanical equip-

ment is concerned, it was deemed advisable to design special mixing equipment quite different from conventional types. Bearing in mind that the natural mixing action of water in flowing around bends induces a pair of oppositely revolving spiral internal currents in vertical planes within the body of the stream, the writer evolved what he has called a "spirovortex" pump. Such a pump will enhance the mixing effect of stirring alone through the actual circulation of the water in the direction naturally assumed by the filaments in vortex flow. The mixing action that occurs when the pump is in operation is indicated in section BB of Fig. 2.

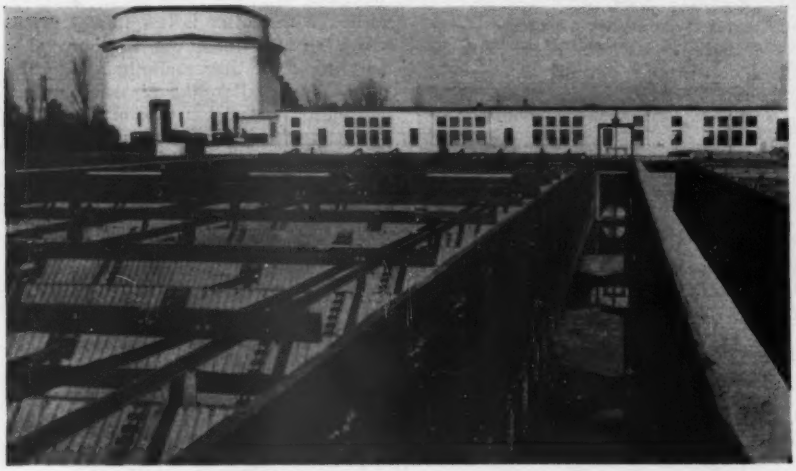


Fig. 7—"Surfasettler" with inclined corrugated plates supported on a light steel framework. Typical influent and effluent channels with double row of inlet and outlet ports are shown at left. The headhouse and filter gallery are shown in the background.

Preliminary tests with these units, which are 14 ft. in height and have a runner diameter of 8 ft., show that in practice the two lower speeds of 15 and 11 r.p.m. are ample for all purposes. The mixing action, as hoped for, is unusually complete and uniform throughout the tank. The corresponding power requirements are somewhat less than 10 hp. per tank, equivalent to about 0.6 hp. per m.g.d. capacity.

Sedimentation—Preliminary sedimentation is effected in two Dorr 100-ft.-square traction clarifiers, and final settling is accomplished in four 44x144-ft. rectangular surfasettlers equipped with Link-Belt sludge collectors. The division of sedimentation into two stages was the logical outcome of several considerations. In the first place the basins of the original plant are arranged to operate in series, with gates and connecting channels in between. From the functional point of view such an arrangement could not be improved upon. Furthermore additional agglomeration of the floc was desired in the clarifiers by operating them in series instead of in parallel, independently of subsequent sedimentation of the finer floc. Experience with the original plant proved that the bulk of the floc settled in the first basin where an agglomerating velocity prevailed, ranging from 0.1 to 0.15 ft. per second. Finally, the decision to use return sediment from the settling basins as an aid in coagulation and further sedimentation, dictated an arrangement whereby the heavy floc and the fine floc might be segregated.

Tentatively, it was assumed that the relatively coarse floc removed by the clarifiers, heavily impregnated with decomposible organic matter during the summer months when artificial turbidity in the form of return sediment is not desirable, should be eliminated promptly from the system; whereas the finer floc accumulated in the surfasettlers, and relatively inert organically, should constitute that portion to be returned to the mixing tanks. Also by this method of operation the return sediment is automatically removed from the system with the coarse floc in the clarifiers after it has served its purpose as an aid to coagulation and settling. Experience at the Wilmington (Los Angeles) color-removal plant indicated the probability of the return sediment becoming septic if re-used several times.

First Stage in Settling—The clarifiers are standard in every respect except for the inlet and outlet arrangements. These comprise influent and effluent concrete channels and individual inlet and outlet ports through the structural walls of each unit.

Contrary to ordinary practice, the channels have been made of unusual cross-sectional area, having as they do a depth equal to that of the side water of the clarifier, and a width of 5 ft., resulting in a velocity of flow in the channels of 1.5 ft. per second at normal capacity. Sacramento experience indicated clearly the value of channels of this size in insuring an even distribution of the flow across the width of the basin, in much the same way as a header channel of adequate cross-section insures a uniform discharge through pipe laterals extending therefrom.

Complete diffusion of the incoming water is obtained through the wall ports. Each port carries an adjustable baffle plate set a short distance from the face of the wall, thus completely checking the forward velocity of the water in a plane parallel to the wall (Fig. 6). Such a design was originally worked out by Professor Hyde in the old sedimentation basins and proved so effective that no improvement appears possible.

Whether such uniformity of distribution will result from the use of baffled ports in a relatively shallow basin remains to be seen, although satisfactory results have already been reported from the preliminary operation of this plant. The arrangement of outlet ports and effluent channels is symmetrical with that of the inlets and influent channels to permit them to operate equally well in either direction of flow through the basins. Besides being operable in either direction of flow, the clarifiers may also function either in series or in parallel (Fig. 2).

Surfasettlers—The form of construction of the surfasettlers was dictated by the requirements of final sedimentation at the Sacramento plant, though showing possibilities for further improvement. The arrangement of inclined plates, shown in Section AA of Fig. 2 and in Fig. 7, provides, in horizontal projection, an area equal to that of the floor of the basin itself, so that the area factor is thus doubled for a given size of basin of this type.

Each of the four surfasettlers is a structural unit, capable of being taken out of service or unwatered while the remaining units continue in operation. The shape of the units was determined to a certain degree by considerations relating to the installation of the sediment-removal equipment. However, the controlling factor was that of limiting velocities of flow through the units. In order to have units of appropriate dimensions in plan, it became evident that the flow would have to be across the basin instead of along the basin if the required subsiding velocities were to be secured, the detention period remaining the same. It was thus decided to make the long dimension of each surfasettler serve as the width of the basin, with the flow passing through the spaces between the inclined corrugated-iron plates. Considerations of span length of the supporting trusses also favored cross-flow as adopted. Had not inclined plates been included in the design it would doubtless have been desirable to substitute a reasonable number of baffles parallel to the line of flow, in order to minimize short-circuiting through the basin. Even so, this does not appear to be necessary in view of the excellent test results reported recently by A. M. Rawn, of the Los Angeles County Sanitation Districts, on a similarly equipped tank of conventional dimensions in which cross-flow was studied for a time. The inlet and outlet arrangements of

the surfasettlers are quite similar to those of the clarifiers.

Auxiliary Treatments—In addition to the standard pre-treatment process, provision has been made for the treatment of the water by activated carbon and the ammonia chlorine process. Inasmuch as specific experience relating to the applicability of these methods is as yet lacking at the Sacramento filtration works, it was decided to install such adjuncts as may be required, after suitable experimentation during actual plant operation.

The Sacramento River water is in general of excellent quality throughout the year, with the exception of a seasonal appearance of algal tastes and odors accompanying low-river stages and the access of return irrigation water to the stream. The elimination of the resulting burden of organic matter presents a technical problem of considerable difficulty. Mention has been made of the possibility of the application of ammonia and chlorine between the pumping station and the grit basin. Provision has also been made for pre- and super-chlorination ahead of the aerators. Activated carbon may be applied in powdered form at a convenient point before aeration and thus be thoroughly mixed in the aeration system, particularly on the stream-flow riffles. If found desirable, powdered activated carbon may also be applied at the entrance to the effluent channel, where baffles may be introduced to effect a thorough mixing of the carbon with the water immediately prior to filtration.

Costs—The new Sacramento pre-treatment plant was constructed under a $480,000 bond issue. The pile foundations cost $63,100, and the superstructures and equipment $380,000.

The rated capacity of the plant is 64 m.g.d., with hydraulic elements designed for a maximum rate of 100 m.g.d. On the basis of the average capacity the contract cost per m.g.d. was $7,000, inclusive of pile foundations, or $6,000 per m.g.d., exclusive of piles. These low costs are believed to be the result of the low prevailing prices in the construction industry and the economical structural and functional design and arrangement of the plant itself.

Personnel—The entire project was planned and brought to successful completion under the administration of James S. Dean, city manager. The structural and functional elements of the complete pre-treatment works were designed respectively by Henry D. Dewell, as consulting structural engineer, and the writer, as consulting sanitary engineer. The work was under the direct charge of Fred J. Kraus, city engineer, assisted by members of the staff of the city engineering department, who supervised the field work of construction. R. R. Mittelstaedt is superintendent of the division of water, with Carl M. Hoskinson as chief engineer and Cornelius Herb as chemist in charge of filtration.

The pile foundations were installed by the Western Foundation Co., of Chicago, and the main contract for constructing the superstructure and equipment of the pre-treatment works was completed by the Campbell Construction Co., of Sacramento, with the Dorr Co., of Los Angeles, and the Link-Belt Co., The Water Works Supply Co. and the Western Pipe & Steel Co., all of San Francisco, as the chief subcontractors furnishing equipment.

How the Highway Pays—II

Vehicle-Operating Economies

Vehicle-operating costs as figured for high, intermediate and low types of roads definitely indicate lower costs on improved surfaces

By R. W. Crum

Director Highway Research Board, National Research Council, Washington, D. C.

IN THE PRECEDING ARTICLE (*ENR*, June 29, p. 834), on liquidation of highway costs on the basis of tax returns from motor vehicles using the roads, reference was made to vehicle-operating economies as an important factor in any evaluation of highway improvements. Based on the best quantitative data, these economies, while small for each vehicle, count up for all vehicle mileage to astounding sums that justify far greater highway expenditures than any that have been generally undertaken. This article presents an estimate of these economies as computed for a specific road and for a state highway system.

—EDITOR.

THE FACT that it costs much less to operate motor vehicles over some types of road surfaces than over others is of great importance in the evaluation of existing and proposed improvements. As a measure of the value of road-surface improvements, it is common to speak of the savings at so much per vehicle-mile realized by the users. While it is true that each vehicle that travels the road does so at less cost than if the surface had not been changed, it is not strictly correct in all cases to call the difference in cost a saving. This is because road improvements in the past always generated additional traffic and therefore actually caused *more* spending for travel rather than less. On the other hand, to that part of the traffic that was using the roads before the change was made there is a very real saving.

General estimates

An economy of 1c. per vehicle-mile by reason of the change from a lower to a higher-type surface does not appear large, but when we pause to consider that such a reduction in the cost of operating the 25,000,000 motor cars of the nation would amount to about $1,500,000,000 per year, the possibilities become enormous.

About 30 per cent of the state highways are as yet unsurfaced. Assuming conservatively that 50 per cent of all road and street traffic is on the state highways, the traffic on the 30 per cent of them that are unimproved amounts to 22,500,000,000 car-miles per year. A decrease in operating cost of 1c. per mile would save $225,000,000 per year. This is a potential economy to be realized when the remainder of the state highways are surfaced.

It is impracticable to evaluate the highway improvement made from the beginning of the automobile era to the present time entirely on the basis of savings, because during that time highway transportation grew with such rapidity and changes in vehicles and roads took place so fast that the bill for highway transportation grew steadily larger; and although great economies were made, they can hardly be expressed as savings in the ordinary meaning of that word. Now that a halt has been called upon traffic expansion, we have an opportunity to take an inventory and evalute what has been accomplished.

Even if we cannot always say that individual motorists have saved a specific amount, the fact that travel is cheaper over paved roads is of great economic significance.

In the study of projected improvements it is quite proper to consider that any decrease in vehicle-operating costs due to the improvement will result in direct savings to the traffic that is using the road at the time the analysis is made. Future increased traffic will also profit by the economical travel provided even though it cannot be segregated as savings.

In any case a first principle of highway economics is that the cost of highway transportation should be the lowest possible consistent with adequate service.

Vehicle-operating costs

An extensive investigation was reported in 1928 by Agg and Carter in *Bulletin 91*, Engineering Experiment Station, Iowa State College. Dean Agg's estimates have been widely used and are generally accepted as authentic. At that time he placed the costs of operating an imaginary "average" auto-

TABLE I — OPERATING COST OF AN IMAGINARY AVERAGE AUTOMOBILE, IN CENTS PER MILE, AFTER *BULLETIN 91*, ENGINEERING EXPERIMENT STATION, IOWA STATE COLLEGE

	Type of Surface		
	High	Intermediate	Low
Operat'g charges, gas, oil, tires, repairs....	2.87	3.69	4.54
Depreciation.....	1.26	1.39	1.57
Fixed charges, garage, insurance, interest..	1.01	1.01	1.01
Road taxes.....	.30	.34	.38
	5.44	6.43	7.50

mobile on three classes of roads as shown in Table I.

The most significant feature of these figures is the difference in operating cost of 0.99c. between the low and intermediate types and 1.07c. between intermediate and high. In a recent paper read before the highway division of the American Society of Civil Engineers, Dean Agg said that recent unpublished investigations would modify these figures somewhat and that he had reached the conclusion "that for economic studies it is on the side of conservatism to assume that the change from a lower type saves to the automobile about one-eighth of the operating cost on the lower type. This amounts to 0.8c. per mile of travel for the 'composite-average' automobile on the basis of 1931 operating costs." He also said, "The data are too fragmentary to permit drawing any very positive conclusions as to the saving to commercial vehicles through change in type of road surface. It is believed that no serious error will result if economic comparisons are based on the average operation cost of commercial vehicles being 22c. per mile of travel and a saving in cost by a change from an intermediate to a high type of 5c. per vehicle-mile."

The road-surface types referred to may be somewhat at variance with those commonly meant by high, intermediate and low when thinking of roadbuilding costs.

The high types in this connection are those with hard smooth uniform surfaces that are practically unchanged through all weather conditions.

The intermediate types are those which, although they are considered to be all-weather roads, vary in surface texture with climatic conditions and sometimes break up under extremely wet weather.

The low types are susceptible to great changes with the weather, some of them becoming practically impassable under heavy rains.

The differences in operating costs quoted above are those shown for regular operation throughout the year, rain or shine, and they are greatly affected by the changes in the intermediate and low-type surfaces that occur with changes in weather.

Under certain conditions it may be just as cheap to drive on a plain dirt road as on a pavement, but the point is that such conditions prevail only a part of the time.

Table II gives some interesting vehicle-cost data that were published by John A. Johnson, district engineer, Massachusetts highway department, in the Feb. 19, 1933, issue of the *Worcester Sunday Telegram*. These were compiled from records of Massachusetts vehicle users, with all costs revised to 1932 prices.

As an illustration, let us consider again the Boston Post Road. This was shown in a former article to be a self-supporting and profitable section of the highway public utility of Massachusetts. The users are apparently being furnished the service they want at a reasonable charge. But it is fair to ask the additional question: Is the cost of transportation on this section economical and as low as possible?

The average annual costs per mile on this road as a high-type surface, taken from the 1930 report of the transportation economics committee of the Highway Research Board, are as follows:

Roadway costs.....	$9,445
6,075,000 automobiles @ 5.44c.....	330,480
675,000 trucks and buses @15.15c.....	102,262
Transportation per mile.....	$442,187

What it would cost the same amount of traffic to use an intermediate type surface is estimated in part to be:

Roadway costs.....	$?
6,075,000 automobiles @ 6.43c.....	390,622
675,000 trucks and buses @20.15c.....	136,012
Vehicle cost per mile.....	$526,634

In this case we do not have any information as to the probable cost of an intermediate-surface roadway, but it is not needed. The vehicle-operating cost alone is much greater than the entire transportation cost on the high-type surface.

It would be going too far to say that because it has a high-type surface every automobile traveling this road saves 1c. per mile, for probably if the road were not so good many would stay at home and save even more. But to those vehicles that would use the road in either case there is a real saving, and of the others we can at least say that the traffic that wants to use the road is being given the service at the minimum cost.

Saving on a state system

The proposed improvement of the Mississippi state highway system previously discussed (*ENR*, June 22, p. xxx) presents a legitimate example of possible real savings to motorists.

At the time the survey was made, in 1929, there were 3,071 miles of untreated gravel and dirt roads on the state system, which carried average year-round traffic of 1,988,003 car-miles per day. Just as soon as these gravel and dirt roads are surfaced, every car that travels on them will do so for at least 1c. less per mile. Without any increase in traffic the saving will amount to $19,880 per day, or $7,256,211 per year, which is almost equal to the annual cost of improving the entire state system.

TABLE II — VEHICLE-OPERATING COSTS IN MASSACHUSETTS, IN CENTS PER MILE

	Road Type		
Vehicle	High	Intermediate	Low
Passenger cars.....	8.02	9.14	11.5[illegible]
Trucks to 1½-ton....	11.86	13.88	18.4[illegible]
Trucks, 1½ to 3½ tons.	20.83	24.41	31.0[illegible]
Trucks and buses over 3½ tons.....	31.56	36.97	46.08

The traffic carried by these roads was about 38 per cent of the entire street and highway traffic of the state and 70 per cent of the state road traffic, and therefore road revenues derived directly from use of these roads amounted to 38 per cent of the gasoline taxes and 70 per cent of the license fees, or $4,360,000 per year. Since it was previously demonstrated that the state highway improvement program could be carried out without increase in rates, the motorists using these roads stand to receive net savings amounting to the difference between total savings and road contributions or $2,896,000 year year. Or to put it in another way, until the roads are improved they are losing that much.

A study of relative transportation costs is necessary in the evaluation of existing highways, but in the future its most specfic application will be in judging of the soundness of proposed improvements. In the article to follow, these relations will be discussed in detail in connection with an individual project.

The high-type roads were those with firm true surface of bitumen, portland cement mixtures or blocks in good condition.

The intermediate types were plain gravel or waterbound macadam in fair condition.

The low types were natural local soil with no surface treatments.

High-Pressure Wind Tunnel

A compressed-air wind tunnel has been installed at the National Physical Laboratory, Teddington, England, for use in aeronautical research. Its principal advantage is said to be that it eliminates variations between model and full-scale results that have been common with lower-pressure wind tunnels. The new tunnel consists of a steel shell in which a wind speed of about 60 miles per hour can be attained at 25 atmospheres pressure. The tunnel is 50 ft. long with an internal diameter of 17 ft. It is made up, without longitudinal joints, by using rings rolled from 112-ton ingots. The steel shell is nearly 2½ in. thick and is designed to withstand an internal pressure of 350 lb. per sq.in. The ends of the cylinders are closed by hemispherical steel castings. The total weight of the steel shell and the internal structure is 350 tons. The air is circulated by a metal air screw driven by a 400-hp. motor. The models are tested in a working section 6 ft. in diameter. Air, circulated by the fan, flows through this section and returns through an annular space surrounding it.

Golden Gate Bridge Work Makes Progress

Concrete is being placed on north pier, and the anchorage site is ready—Subaqueous blasting and excavating half completed for south pier—San Francisco anchorage site excavation under way—Two batching plants for truck-mixers are completed

EXCAVATION for the piers and anchorages of the Golden Gate Bridge at the entrance of San Francisco Bay is well advanced, and concreting operations have started on the Marin County (north side) pier. The San Francisco pier site, 1,000 ft. offshore in water 65 ft. deep, has been excavated 20 ft. through rock by subaqueous blasting and dredging to within 15 ft. of final foundation elevation. Preliminary work on the San Francisco anchorage site involved changes in the seawall and structures in the U.S. military reservation that have now been completed. Aggregate batching plants have been completed on both sides of the site that will be used jointly by contractors to prepare material to be transported in truck-mixers to the points of use.

The Golden Gate Bridge will consist of a 4,200-ft. suspension span between towers 746 ft. high above water level, with balanced 1,125-ft. side suspension spans and a steel viaduct structure aggregating a total length of 9,217 ft. The structure will be 90 ft. wide between stiffening trusses, including a 60-ft. roadway and two 11-ft. sidewalks carried along the top-chord level of the trusses. The two cables will be 36½ in. in diameter with 830 sq.in. of steel. The towers, of fixed-base flexible type with cables fixed at the top after erection, are of cellular-leg design 699 ft. high from pier top to the center of the cable.

The structure is being built as a publicly owned toll bridge by the Golden Gate Bridge & Highway District, consisting of San Francisco County at the south and five counties north of the Golden Gate. The district voted a $35,000,000 bond issue in the fall of 1930, and after an extended delay in the courts the legal features were approved by the state supreme court and the federal court. A sketch of the project's history and a description of the principal design features appeared in *Engineering News-Record*, May 28, 1931, p. 890. The progress of actual construction operations, which have been confined to the two main pier and anchorage sites, is as follows:

Looking north across the Golden Gate, showing old Fort Scott in the foreground, which will be spanned by an approach arch, and the 1,000-ft. trestle to the pier site. The U.S.S. "Constitution" is shown entering the bay.

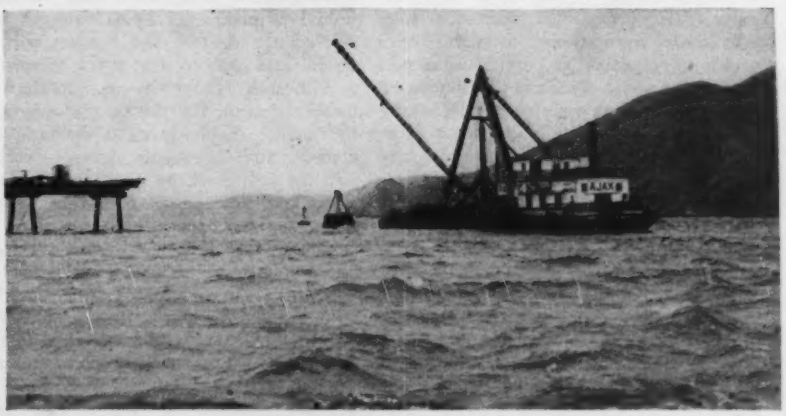
San Francisco pier

The site for the San Francisco pier is about 1,000 ft. offshore in water 65 ft. deep. There is no overburden, as the tidal flow through the gate, which reaches a 5-m.p.h. velocity, keeps the rock swept clear. Preliminary construction operations consisted of building a trestle to the location. This trestle, 24 ft. wide, was built on timber piles for 400 ft. to a 30-ft. depth of water, and the last 600 ft. consists of structural-steel bents set in pipe casings. The piles and the pipe casings were driven to refusal into a shattered area loosened by subaqueous blasting. A crane on a 10-ft.-gage track operates on this trestle, and material is handled by a car moved by a cable on the same track.

The pier is 185x90 ft. and is designed to rest on rock at El. —100, according to the original plan. The ultimate need for a fender system around this pier resulted in a design that used the fender structure as an inclosure to aid in constructing the pier. The original plan was to construct this reinforced-concrete fender on existing rock and subsequently to sink the caisson for the pier inside this fender as a protection from tide and heavy seas. Specifications required that the pier be founded on rock by the pneumatic process to permit careful examination of the foundation.

The contractor for the main piers presented an alternate plan for the construction of this pier, which was accepted and is now in use. Briefly, the plan required the subaqueous excavation of the entire pier and fender site to about the level of the pier foundation at El. —100. After this has been completed the fender will be constructed, using structural units 27 ft. wide (thickness of the fender) and 35 ft. long,

Derrick barge excavating rock loosened by subaqueous blasting at the San Francisco pier site.



which will be sunk to rock, inclosed on the sides and filled with concrete. When this fender construction has been extended to form a horseshoe shape, the caisson will be floated into position and the fender will be completed. After placing a sand cushion over the site the caisson will then be sunk, with the usual process of building up the concrete pier, until foundation rock is reached. A 3-ft. clearance is provided between the pier and the inside of the fender.

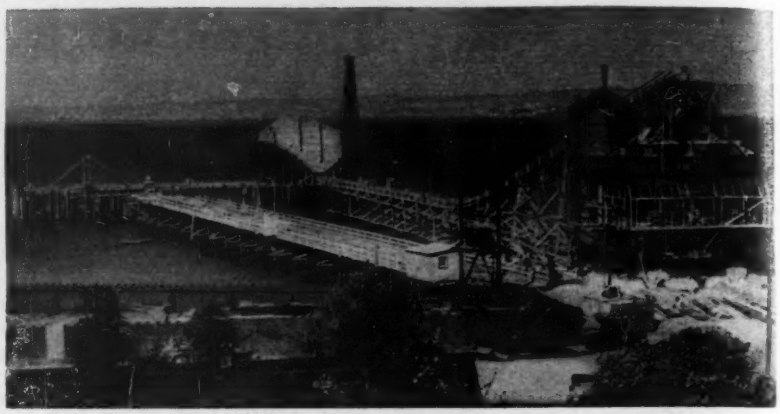
With the caisson resting on rock, air pressure will be put on, and a small amount of work will be required under high air pressure to build forms under the cutting edge to permit the 3-ft. space between pier and fender to be filled with concrete up to the original rock elevation. Above this a clay fill will be added up to the bottom of the base block (El. —50). The small amount of form building will be the only operation requiring high-air-pressure working conditions. After the space between pier and fender is filled with concrete placed by tremie, the caisson will be unwatered or at least the water kept out by a low pressure of air. With these operations completed, the sand cushion over the foundation rock can be excavated and the surface prepared for the final concreting of the pier foundation.

The advantage of this operation is the elimination of caisson sinking through a 35-ft. rock depth under air pressure. It has necessitated, on the other hand, the subaqueous drilling and excavation of rock from 65 to 100 ft. below water surface, and these operations have provided the principal feature of construction interest to date. The details of the pier and fender excavation and construction will be described in a future issue.

North pier and anchorages

The north pier is located at the shore at the base of a steep cliff about 250 ft. high. A shelf of rock at this location provided a suitable foundation at about El. —20. The site was unwatered by constructing a combination timber-crib, sheetpiling and earth-embankment cofferdam inclosing three sides of the pier site. Behind this embankment the excavation has been completed. Over almost the entire pier site the rock conditions were found to agree with preliminary plans, and excavation was leveled off at El. —20; at the southwest corner conditions required a deepening of the excavation to El. —32 as a maximum. This work has not provided any unusual features either as to the cofferdam or excavation procedure. Leakage through the cofferdam is being lifted from a sump by a 16-in. pump.

The concrete for this pier will form a block 160x80 ft. in plan and 65 ft. high. Concrete placing was started late in May, using chute distribution from a hoisting mast. Concrete is delivered to the site in truck-mixers from a batching plant.



View of aggregate plant on the San Francisco side, which is duplicated on the Marin County side. Aggregate and cement are delivered by barge, elevated by conveyor belt and prepared in 4-yd. batches for the truck-mixers.

Excavation for the two gravity-type anchorages, under another contract, involves the handling of about 200,000 cu.yd. of unclassified material and the placing of almost 150,000 cu.yd. of concrete, including the embedding of the cable-anchorage steel. On the north side (Marin County) the excavation has been completed and the foundation area has been prepared. A 250-ft. structural-steel hoisting tower and chutes will be used to cover the area.

The San Francisco anchorage site is at the water's edge, in the U.S. military reservation, necessitating alteration of the protecting seawall as a preliminary operation and the moving of some government structures. This work has now been completed. Old Fort Scott at the water's edge is to be left in place for historic reasons. Excavation work, however, is well under way on the total estimate of about 125,000 cu.yd.

Partnership concrete mixing

By agreement between the contractors for the various contracts on the project, a central batching plant has been erected at the water's edge at each end of the bridge. Material will be delivered to these plants by barge and proportioned and delivered as required by the various contractors in accordance with the individual requirements as to strength and size of aggregate. The batches will be mixed and delivered in truck-mixers.

Although differing in details of bunker design, the plants are generally the same. Each provides dockage for cement and aggregate barges, which will be delivered by tow on the bay. Sand and four sizes of coarser aggregate, up to a maximum size of 6-in. cobbles, will be handled by grab buckets on cranes and unloaded into timber bunkers. These bunkers are provided with gates discharging onto a conveyor belt that will deliver the material to the bins above the batching plant. Bulk cement arrives in covered barges and is pumped out of the barge and then boosted by a larger pumping unit up to the steel silos above the plant.

Each plant contains two modern weighing units for preparing 4-cu.yd. batches. Sand and the four grades of aggregate are measured by the operator through an interlocking system governed by a photoelectric cell, which does not permit the next aggregate bin to be unlocked until the required amount of aggregate is in the hopper. This weight control is regulated for any proportion of batch by a locking arrangement set by the engineer. Water is measured by meter, and the cement is weighed in a separate automatic scale. The 4-yd. batches and the water discharge directly into 4-yd. truck-mixers that deliver the concrete to the point of pour. A locking mechanism on each truck is timed to start when the mixer has attained a peripheral speed of 180 ft. per minute. After this speed has been attained, the truck driver cannot obtain his ticket, which must be delivered to the inspector at the point of pour, until the end of a 6-min. mixing period. Each of these plants will be used to provide concrete for a pier, anchorage, foundation for approaches and deck paving. The estimated amount of concrete to be prepared at both plants is about 325,000 cu.yd.

Organization

The Golden Gate Bridge is a publicly owned toll bridge and is being built by the Golden Gate Bridge & Highway District under the direction of James Reed, general manager. Joseph B. Strauss is chief engineer for the district in charge of design and construction. R. G. Cone is resident engineer. The contract for the two main piers is held by the Pacific Bridge Co., Portland and San Francisco, on a bid of $2,935,000. C. F. Swigert is president of the bridge company and is personally directing operations, with J. G. Graham as superintendent. The contract for the two anchorages and for the piers for the approach spans is held by Barrett & Hilp, San Francisco, with a low bid of $1,859,000. O. F. Woodward is superintendent. The batching plants were constructed, and the aggregate is furnished by Pacific Coast Aggregates, Inc.

Difficult Caisson Sinking for Vancouver Water Tunnel

Open dredging used to sink 24-ft.-diameter caisson 130 ft.—Large boulders encountered at 100 ft. drilled and blasted by diver—Landed on sandstone, sealed and pumped out as start of 400-ft. shaft

By William Smaill
Chief Engineer
and R. M. Wynne-Edwards
Northern Construction Co. and J. W. Stewart Ltd.

BOULDERS removed by blasting in a 100-ft. depth of water and final jetting through 15 ft. of shale were the special problems encountered in sinking a caisson 130 ft. to rock by open dredging as part of the pressure tunnel being built by the Greater Vancouver Water District under the First Narrows at the entrance of the harbor at Vancouver, B. C. Completed and unwatered, the caisson provided the start of a 400-ft. shaft required to reach rock through which the 3,100-ft. tunnel could be driven. The original plan to sink under air was successfully changed to open dredging, although extreme care and judgment were required to found and seal the caisson on rock. An outline of the project, its relation to the Vancouver water-supply system and the progress of the work appeared in *Engineering News-Record*, Jan. 12, 1933, p. 56.

The tunnel will replace the present system of submerged mains used to bring the city's water supply across the Narrows from sources north of the harbor. It consists of two 400-ft. shafts and 3,104 ft. of 7½-ft.-diameter tunnel. The south shaft is in Stanley Park, Vancouver, where sandstone bedrock is within a few feet of the surface; the north shaft is located on the tide flats across the Narrows. Borings indicated that these tide flats consist of tightly packed sand and gravel (brought down by Capilano Creek) about 100 ft. deep, overlaying the weathered surface of shale bedrock. No core was recovered for 130 ft. below high water. As a result of the 100-ft. depth of water-bearing gravel above bedrock at the location of the north shaft, it was necessary to sink a caisson to a satisfactory foundation, seal it and finally excavate through the seal to continue the shaft in the rock. The problem was hazardous, necessitating careful judgment on the determination of a satisfactory foundation that would safely permit an open shaft to be sunk through the seal and into the rock below.

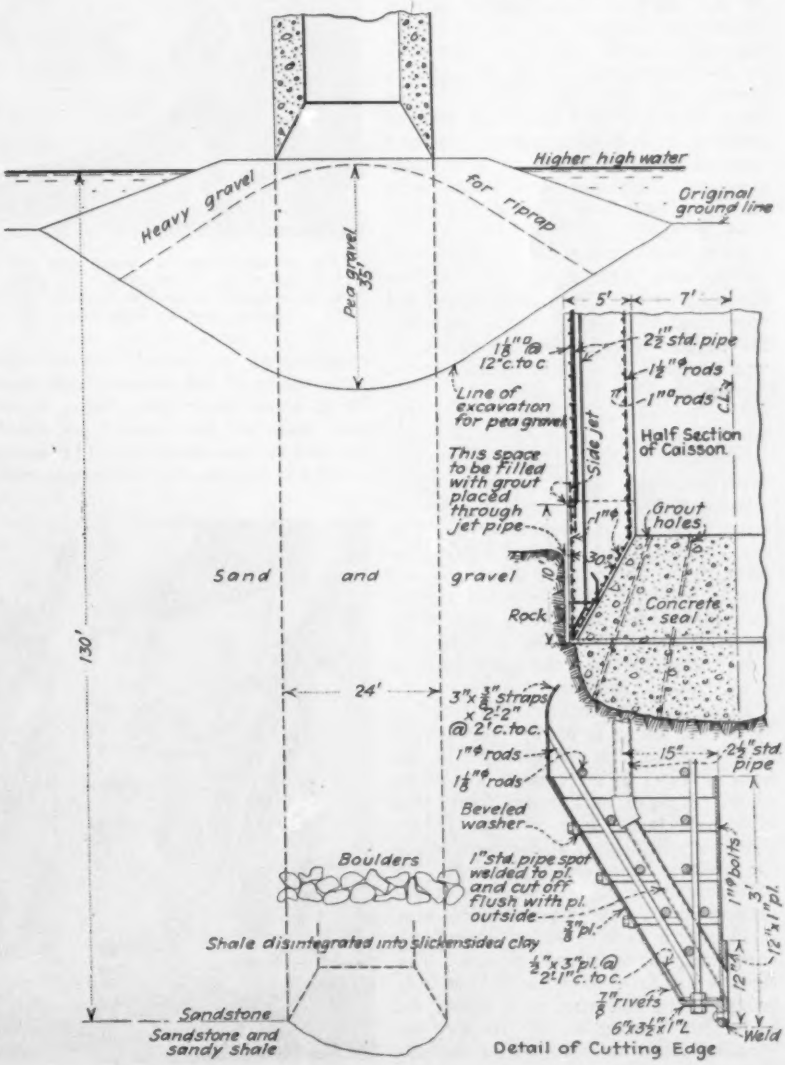
It was originally intended that the caisson should be sunk under compressed air, but in view of the high pressures that might be required before the caisson reached rock the contractor asked for and received permission to try open-dredging methods, offering to make a $50,000 reduction in price and, if the method failed, to proceed under air at his own expense.

The caisson design in the contract drawings was cylindrical in shape, with an internal diameter of 14 ft. and 3-ft. concrete walls heavily reinforced. To avoid, if possible, the use of additional weight to overcome skin friction, the contractor decided to increase the walls to 5-ft. thickness, making the outside diameter 24 ft. (Fig. 1). In view of this increased thickness the quantity of reinforcing was reduced. To decrease skin friction, it was decided to excavate the sand and gravel at the caisson site for about 30 ft. previous to constructing and to backfill the excavation with pea gravel, which would tend to reduce the friction as a result of having particles of about uniform size.

After this had been done, an island of heavy gravel was built up 8 ft. higher than the surrounding flats to facilitate setting up the cutting edge and placing the first concrete above high tide. A framework of timber piles trussed together with heavy timbers was built to form a working platform and to act as guides during the early stages of sinking.

The cutting edge was formed by

Fig. 1—Materials encountered in sinking, caisson section and details of cutting edge.



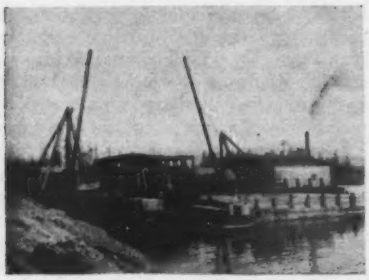


Fig. 2—General arrangement of surface plant. Larger derrick at left handled excavation and concrete. Smaller derrick at right moved aggregate and steel.

sloping the inner wall of the caisson out at 30 deg. with the vertical to form a bell, and it was shod at the bottom with a light structural-steel shoe (Fig. 1). This shoe consisted of plates and angles riveted and welded together. The actual cutting edge was 6 in. wide, and the plates protected the concrete on both sides to a height of 3 ft.

Before sinking operations were started the caisson was built to a height of 30 ft. To provide additional bearing while this concrete was being placed, the steel shoe was filled with gravel up to the top of the plates as soon as placed, and later the entire bell was filled with gravel. The concrete was about a 1:2:3 mix, with 2 per cent calcium chloride added to give early strength. Sectional steel forms were used for both walls. When the forms were stripped after each 8-ft. pour, the top ring was left in place to form a base for the next form set-up. The surface of each pour was thoroughly cleaned and roughened with picks; as a result, when the caisson was finally pumped out, it was entirely watertight from top to bottom.

Excavation was done with a 1½-cu.yd. clamshell bucket or a 2½ cu.yd. orange-peel bucket. Little trouble was experienced for about 100 ft. of penetration, but at that depth a mass of large boulders was encountered. The first boulder, which weighed 5 tons, was successfully slung by a diver and removed, but the rest were too tightly embedded under the cutting edge to be removed either by means of slings or pins. Blasting was the only solution to this serious problem.

Holes for the charges were drilled by divers using a heavy jackhammer drill. The back pressure caused by the head of water in the caisson was about 48 lb. per sq.in., but it was found that even with large hose at least 175-lb. pressure was needed at the compressor for effective operation of the drill. To prevent damage to the concrete in the caisson walls, the charges were kept small, half a stick of 40 per cent dynamite being the maximum charge. The shots were fired electrically, one hole being drilled and shot at a time. As a further precaution to reduce the bursting effect of the sudden concussion on the caisson walls, a compressor was allowed to discharge out of an open pipe at the bottom of the caisson.

By this method several cubic yards of boulders were removed, and the caisson was sunk slowly, but without damage, an additional 8 ft. to the surface of what had once been bedrock. This material consisted of shale weathered and disintegrated by glacial action into a soft slickensided mass, almost a sandy clay. The caisson, therefore, had to be sunk through this material before a safe foundation could be reached.

In building the caisson a number of 2½-in. pipes, with a 1-in. outlet at the cutting edge, had been left in the concrete spaced evenly around the circumference. A second ring of pipes had outlets in the caisson wall about 10 ft. above the cutting edge. It had been intended that these pipes should be used for two purposes: (1) during sinking operations the lower ones could be used as water jets to assist in excavating the material below the cutting edge and the upper ones as outlets through which to force air or water to reduce skin friction; (2) as grout pipes to fill any spaces that might be left between the caisson and the rock. It was found, however, that as water jets the lower ring were useless because they continually plugged so tightly with sand that it took an hour or more to clean each one out. The upper ring of outlets pointed upwards and did not plug so readily, but when air was forced through them the bubbles apparently did not rise close to the caisson wall but showed on the surface of the ground anywhere from 2 to 200 ft. distant.

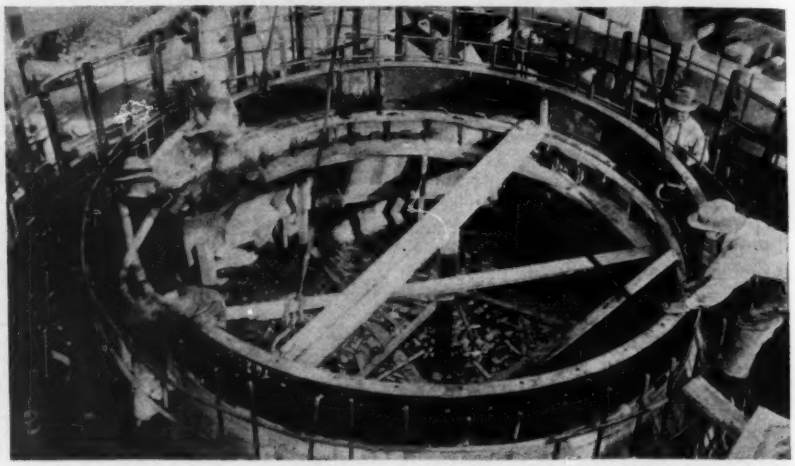
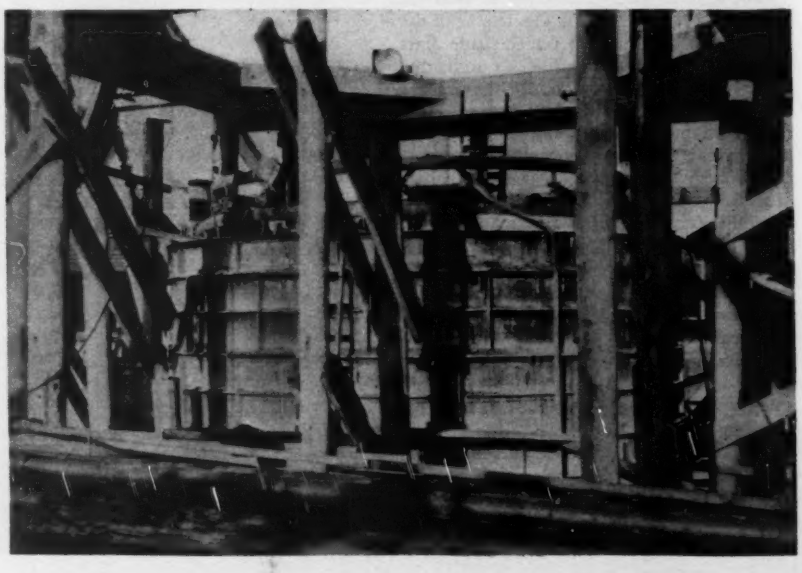


Fig. 3—Assembling the cutting edge and bell steel on the gravel island. Jet pipes to be embedded in the 5-ft. concrete wall appear along the back side.

When it was found that the disintegrated shale could not be readily excavated with an orange-peel bucket, it was decided to build a water jet out of 4-in. pipe with a special cast-steel nozzle, and to operate it as a separate

Fig. 4—Top of caisson, showing steel forms, timber-piling guide frame and manifolds for supplying water to jet pipes.



unit with the derrick. In conjunction with this a sand jack or ejector was used to suck out the fine material washed out by the jet. Water was delivered by a centrifugal pump at 165-lb. gage pressure. Various lengths of bent pipe were used to reach under the bell, and careful watch of jetting operations was maintained by frequent diving inspection. The jet proved very efficient, and the caisson was sunk an additional 15 ft. until the cutting edge was about 125 ft. below high water.

During the period of sinking through the boulders the surrounding material began to slough in under the cutting edge. As the sinking proceeded this sloughing almost always accompanied a movement of the caisson, the flow of the gravel cutting a channel through the softer material below. These movements of gravel caused local settlements up to the surface of the ground, the gravel apparently forming chimneys. As a result, when the action of the jet showed that the caisson was approaching rock, excavation was carried forward carefully in an endeavor to stop the slough, and no excavation was done near where the slough channel showed. Finally, the caisson was dropped the last 18 in. to its final position in one movement and the sloughing was effectively stopped.

About 125 ft. below high water, layers of hard sandstone were encountered with strata of softer material between, and it was in one of these layers of sandstone that the cutting edge was finally founded. Under the center of the caisson excavation was carried down to a depth of 3 or 4 ft. until a ledge was reached that the jet would not cut, although left for an hour in one place. An inspection of the bottom showed that the foundation was adequate as far as bearing was concerned, and that a reasonably watertight seal could be obtained in the rock. The caisson bottom was cleaned up, and a 12-ft. depth of concrete was placed by bottom-dump bucket to form a seal. The bottom-dump bucket was used in preference to a tremie in order to place the concrete as close to the rim of the caisson as possible. The buckets were dumped successively around the edge of the caisson, tending to force any soft material to the center where it would later be removed. Placing operations were successful, but calcium chloride was used in the concrete, and this caused some of it to set up too fast, forming lenses, so that when the shaft was sunk through the seal, laminations of poor concrete were found in places.

After the concrete had set and the water was pumped out of the caisson, test holes were drilled through the seal. The first hole disclosed the presence of water in the seal, but as the flow did not increase when other holes were drilled, excavation was started and a 6-ft.-diameter shaft, afterwards enlarged to a 10-ft. diameter, was sunk through the seal. In sinking the shaft the concrete was blasted out in the ordinary way except that the rounds were shallow and the charges light. Cut holes were shot and mucked out before the relievers and rim holes were drilled. The concrete in the seal was not cracked or damaged in any way by this blasting.

On reaching the under side of the seal it was found that there was no leakage between the seal and the rock, but that about 1½ gal. per minute came through the laminations of poor concrete in the seal itself. This water probably came from some place where there was a small gap between the cutting edge and the rock. The entire seal was grouted and the flow of water ceased. In the meantime many of the jet or grout pipes that had been built into the walls of the caisson were successfully cleaned out, and grout was forced around the outside of the bottom of the caisson. The remaining 270 ft. of shaft was then sunk in the rock without difficulty.

The work was carried out under contract for the Greater Vancouver Water District, E. A. Cleveland, chief commissioner, and W. H. Powell, engineer. F. C. Stewart is resident engineer. The contractor is the Northern Construction Co. and J. W. Stewart Ltd., with N. D. Lambert as general superintendent and William Smaill as chief engineer.

H. E. Carleton is general superintendent on the tunnel project, and R. M. Wynne-Edwards is in charge of the caisson operations.

Demoistured Air Aids Madden Dam Cement

Handling difficulties caused by the annual eight-months rainy season in Canal Zone are overcome by using sealed steel silos, pneumatic transportation and demoistured air

By Adolph J. Ackerman

Formerly, Chief Engineer, W. E. Callahan Construction Co., and Peterson, Shirley & Gunther, Contractors, Madden Dam, Canal Zone

THE CONSTRUCTION of Madden Dam in the Panama Canal Zone requires about 700,000 bbl. of cement. The design of a suitable plant for economically handling such a large quantity was complicated by the necessity of receiving the ocean shipments in large increments and storing the cement with adequate protection against very damp climatic conditions.

In the Canal Zone the dry season starts around Jan. 2 and lasts until around May 5. The remainder of the year is the wet season. The annual mean relative humidity in the vicinity of the dam site is about 85 per cent. Relative humidities of 100 per cent may be expected during the mornings of the wet season, as compared with 50 per cent or lower during the afternoons of the dry season. A day without rain during the rainy season is exceptional, precipitation records of the past twenty years show a minimum annual rainfall of 72 in. and a maximum of 152 in.

This article describes the general layout of the cement-handling plant and some of its special features, supplementing the description of the concreting plant at Madden Dam, which appeared in *Engineering News-Record*, Dec. 8, 1932, p. 671.

All cement is furnished by the U. S. government, which holds contracts with several American cement mills. The Madden Dam contractors are required to give the government 90 days' advance notice of their cement requirements, and the government reserves the right to deliver requirements for two weeks in one shipment. Shipments arrive at Cristobal in 12,500-bbl. lots every other week, and during the heavy concreting period of 1933 such lots are being received weekly. The cement is loaded from ships into box cars in quantities of 232 bbl. per car and is carried by the Panama Railroad 30 miles to Madden Siding, where it is turned over to the contractors.

Earlier experiences on the Panama Canal had shown paper bags to be the most satisfactory protection against moisture accumulation in transit, as well as in tropical storage, and they were adopted. The specifications for the bags call for six plies, with the one next to the inner one paraffin-coated. All seams must be glued with a special moisture-resisting compound except over the filler valve.

The storage facilities of the contractors consist of two steel silos, each having a capacity of 6,650 bbl. of bulk cement. This is comparatively small, but demurrage on cars has been taken into account and will be permitted to occur to an amount equivalent to the non-salvageable cost of additional storage capacity.

At Madden Siding eight cars at a time are spotted under a shed alongside

a belt conveyor, four on each side, and are unloaded manually with the aid of gravity roller conveyors extending from the belt back into the car. Unloading is maintained at the rated capacity of the cement pump, which is 210 bbl. per hour. The 24-in. belt, driven by a 10-hp. motor, carries the sacks at a speed of 150 ft. per minute to the bulking machine. To insure uniform feed into this machine and full-capacity operation without overloading, the belt is painted with graduations at proper intervals for spotting the sacks.

The head pulley is elevated so that the bags dropping off the end of the conveyor acquire a high velocity as they fall through the bag cutter. This consists essentially of a chute with adjustable sides; at the lower end stationary steel knives are mounted with their tips extending into the chute sufficiently to slit the falling sacks at four points. Any knife may be replaced by a resharpened one without shutting down the plant.

At the lower end of the chute the sacks drop into a 40-in.x10-ft. rotary screen, fully inclosed and revolving at 20 r.p.m., where the cement is effectively removed, dropping into a hopper, while the paper is discharged at the end of the screen. The position of the knives and shape of the chute outlets are designed to open the bags so as to cause the least amount of cement to become lodged between the plies while the sacks are being tumbled around in the screen.

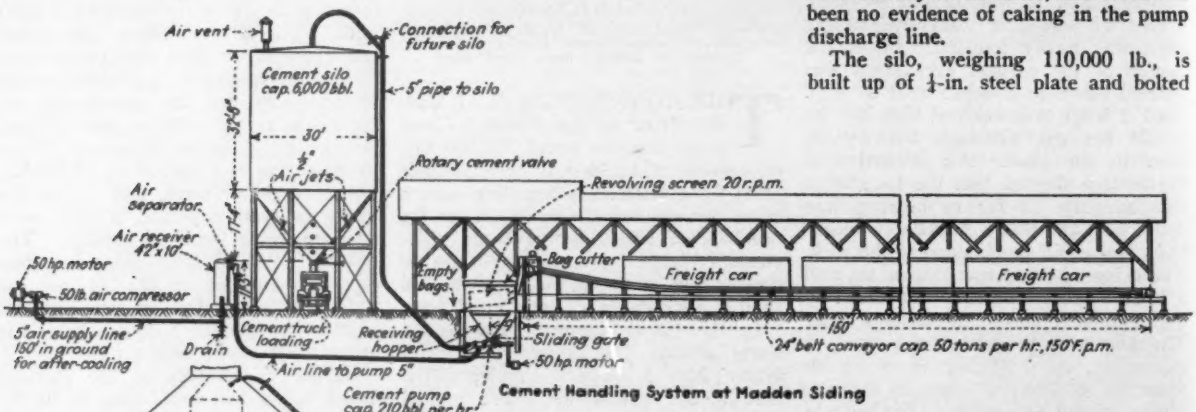
Condition of paper sacks as they come from the bulking device.

The disposal of bags is handled by native labor rather than mechanically, and consists essentially of shaking the bags once or twice and throwing them into large wheelbarrows in which they are hauled to a near-by fire and burned.

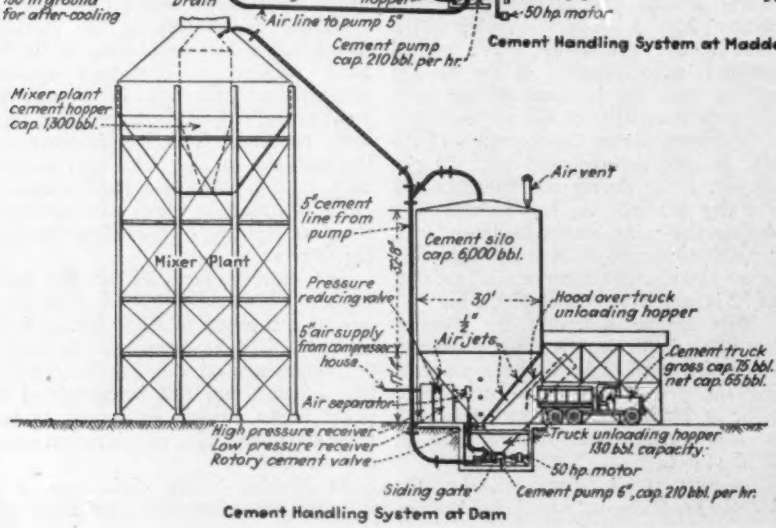
The cement is fed into a pump and conveyed by air 70 ft. vertically into the steel silo. The air supply for the cement pump is delivered at the rate of 238 cu.ft. per minute under pressure of 40 to 50 lb. per sq.in. Every precaution was taken to insure a supply of dry air, even under most severe atmospheric moisture conditions. To accomplish this, the air compressor, which is of the rotary type, was located at the far end of the car shed, and a 5-in.-diameter air line was buried in the ground to produce the effect of an aftercooler. At the other end of the shed an extra-large air receiver was installed where further slight condensation can take place, and finally a small mechanical air separator, with automatic water ejector, is located in the line between the receiver and the cement pump to catch a further small amount of moisture. Before this system was placed in operation, humidity indicators were inserted in the air lines to test the effectiveness of the system in reducing the relative humidity of the air, and it was found that under conditions of 100 per cent relative humidity at the compressor suction this figure was reduced to 65 per cent by the time the air reached the cement pump. The system since then has operated very satisfactorily at all times, and there has been no evidence of caking in the pump discharge line.

The silo, weighing 110,000 lb., is built up of ¼-in. steel plate and bolted for easy salvage. It has a diameter of 30 ft. and is elevated on columns to permit hoading trucks from the under side. Part of the loading zone has been housed as protection against the driving rains. The bottom cone was assembled with flat-head bolts in countersunk holes to reduce the tendency of the cement to arch; in addition to this, air jets were installed over the entire lower portion of the cone, with separate valves for each pair of jets for breaking up arches. The bottom of the cone is equipped with a rotary gate and a canvas spout for loading the cement trucks. At the top an air vent of special design releases the air from the cement pump without undue loss of cement.

Cement-handling plants at railway siding and at dam site include closed steel silos and pneumatic conveyors that are operated by demoistured air.

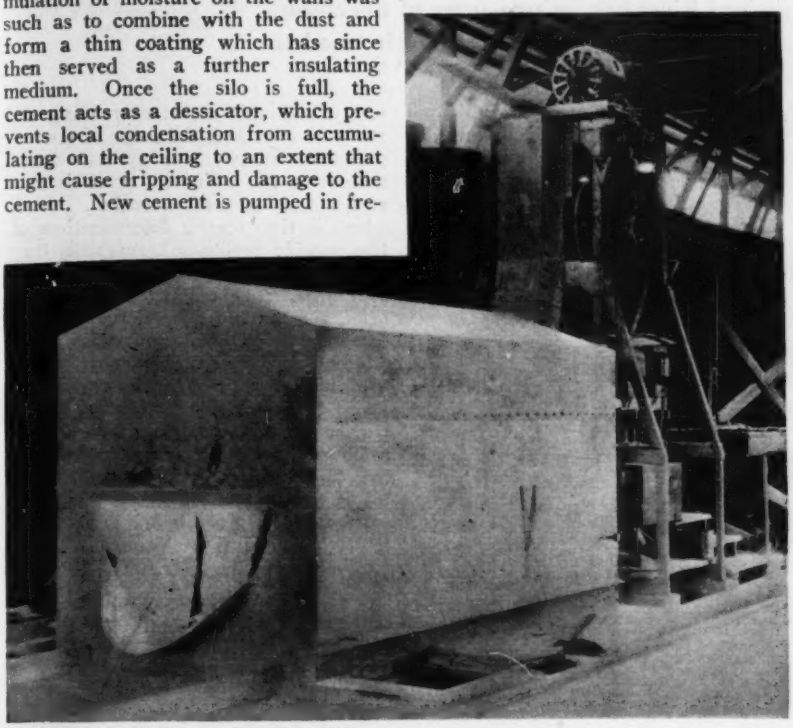


Cement Handling System at Madden Siding



Cement Handling System at Dam

Every precaution was taken to prevent moisture from entering or forming in the interior of the silo. All joints and bolt holes were painted with asphalt, and the entire silo was painted with aluminum paint because its reflective power is known to reduce condensation or sweating on the inside. Careful tests were made with humidity indicators, and while it was not possible completely to dry out the silo before placing it into service, the accumulation of moisture on the walls was such as to combine with the dust and form a thin coating which has since then served as a further insulating medium. Once the silo is full, the cement acts as a dessicator, which prevents local condensation from accumulating on the ceiling to an extent that might cause dripping and damage to the cement. New cement is pumped in frequently enough to prevent formation of a crust on top of the contents, and only one or two barrels of cement is lost each month from small leaks.



Paper-bag opening and removing device changes sack cement into bulk cement for pneumatic handling.

Trucks for hauling cement

From Madden Siding to the concrete plant at Madden Dam the cement is hauled by trucks a distance of 13 miles, mostly over paved highway of easy grades and turns. Pneumatic tires are required by government regulation. Three standard 10-ton trucks are employed, having hydraulic-hoist dump-body frames. The bodies are of job design and are built in the Balboa shops of the Panama Canal for a full capacity of 60 bbl., and they carry an actual average of 54 bbl. per load. They are built up of ¼-in. bottom plates and ⅜-in. sides, with rounded fillets in the bottom to reduce hangover, and with the rear 6 in. wider than the front for easier dumping. The end gate rests against a rubber seal. The top is vented and was originally built with three filler holes, but it was found that the central one is sufficient. The entire top is removable to make the bodies convertible for hauling other materials. Very little time is consumed in loading and dumping, each truck averaging about fifteen loads in twelve hours.

Handling at mixer plant

At the mixer plant, which is located immediately adjacent to the Madden Dam, the silo is in many respects similar to the one at the siding, except for the fact that it was not elevated on columns but was designed with the bottom of the cone on a level with the surrounding ground. A continuation of the cylindrical plates to the ground serves as a means for supporting the silo. Here the trucks back into a shed and end-dump into a hopper directly under the silo. Less dust or loss of cement occurs in this operation than might normally be expected. A second pumping unit below the hopper carries the cement into the silo or directly to the mixer plant. At other times cement is drawn from the silo back into the hopper and pumped into the mixer plant, where 1,300 bbl. (almost enough for one shift) may be stored at one time.

Conclusions

Experience with the present plant has demonstrated that pumping cement in humid and damp weather can be readily accomplished and storage in steel silos is satisfactory and economical. With the present system there is no dead-storage space, and the flow of cement provides for a complete recirculation as a guarantee against accumulations of aged cement. The handling loss at the bulking plant is about 0.2 per cent in dust, spillage and hangover on the bags. The transportation loss, including filling and dumping, amounts to an average of 0.16 per cent. These losses compare favorably with generally experienced losses of 1 to 1.5 per cent.

Personnel

The Madden Dam was designed by the Bureau of Reclamation for the Panama Canal and is being constructed under the supervision of the Canal Zone Administration, including Julian L. Schley, governor; Colonel C. S. Ridley, engineer of maintenance; Major J. C. Mehaffey, assistant engineer of maintenance; and E. S. Randolph, construction engineer. For the contractors, Paul Grafe is managing director, and R. M. Conner is general superintendent. The writer was in direct charge of the design and erection of this plant.

Closed trucks haul cement from siding plant to mixing plant at dam.

NEW PLANS FOR THE MISSISSIPPI

River Model Design and Operation

Third of a Series of Eight Articles

The U. S. Waterways Experiment Station at Vicksburg on the Mississippi River has, in two years of operation, set criteria for the technique of river study by models

THE NEW ACTIVITY in channel straightening and slope regulation on the lower Mississippi has received definite support from model experimentation, as has been emphasized in the two preceding articles. This technical aid has been exercised through the agency of the hydraulic laboratory established in 1929 at Vicksburg, Miss., and officially designated as the U. S. Waterways Experiment Station. This fact warrants a review and summary of the laboratory operations.

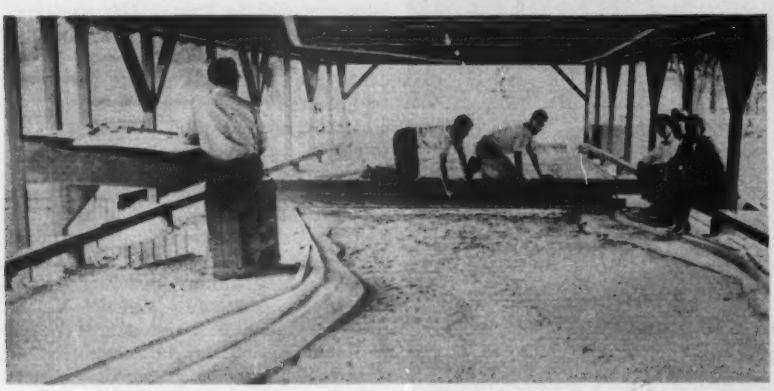


Fig. 1—Scaling and recording bed cross-sections in drained river model after completion of a test run.

The Vicksburg laboratory and its fixed equipment were described in *Engineering News-Record*, July 16, 1931, p. 84, and results of some of the early tests were published at that time and in the preceding issue of June 11, 1931, p. 979. The movable equipment of models has changed many times. Since experiments were begun, more than 60 models have replaced one another in the great hall of the laboratory building and in the large testing field outside.

Objectives are broad

The U. S. Waterways Experiment Station was created by the act of 1928 authorizing the present Mississippi River flood-control project. It was located at Vicksburg, Miss., to be close to the headquarters in that city of the Mississippi River Commission and the army engineer division of the lower Mississippi valley, which have direct charge of the river work. Primarily its services were to be for the Mississippi River improvement, but they were also to be available to all divisions of the army engineer organization in charge of waterways.

In correspondence with its origin, investigations at the laboratory have been largely of problems of Mississippi flood protection and navigation, but they have included also studies of river, harbor and shore-protection problems in other jurisdictions of the army engineer corps. No commercial testing is done, but in certain investigations, as in one of the early studies to determine the characteristics of bends in dredge pipe, participation is arranged with manufacturers. For investigations for engineer districts outside the jurisdiction of the lower Mississippi valley division a charge amounting to cost is made.

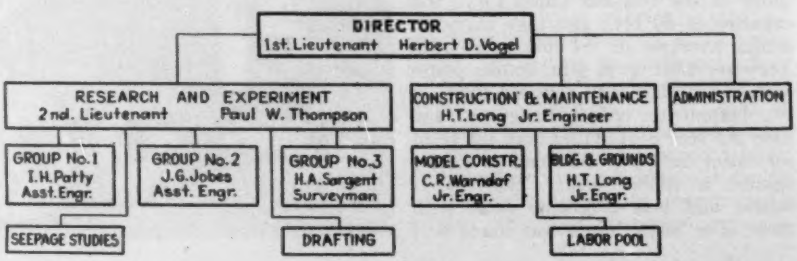
While major investigations have been to determine specific problems arising in planning general operations or individual works, broad stream-hydraulics research is an active part of the laboratory work. In case, after a specific question is answered, there appears opportunity with this model of refining the study or extending the scope of the experimentation to more general determinations, the additional work is carried out as general research. Also, where in time several determinations of like specific problems accumulate, they are given group study, which may provide broader general conclusions. In brief, specific and general research are combined as fully as practicable. In addition, as there are purely specific project studies, there are purely general investigations having no relation to any particular project; among these are the sediment and bed-material determinations and the levee-seepage studies now in progress. The full list of major investigations is given in the accompanying tabulation; it indicates the range and variety of the laboratory studies.

Organization is simple

The general organization for carrying on the laboratory operations under the division engineer and commission is indicated by Fig. 2. The personnel is fixed at about 70, but it is increased at times of extensive outside-model construction, often to double this number. The steady force consists of survey men, draftsmen, assistant engineers, engineer inspectors, carpenters, tinners, photographer and about 40 laborers. The increase in force for special work consists mostly of laborers. At times of running tests the interested engineer districts often send observers to augment the technical force of the laboratory in charge of the test.

The organizaiton procedure is substantially as follows: A submitted pro;-

Fig. 2—Organization chart for the operation of the U. S. Waterways Experiment Station at Vicksburg, Miss.



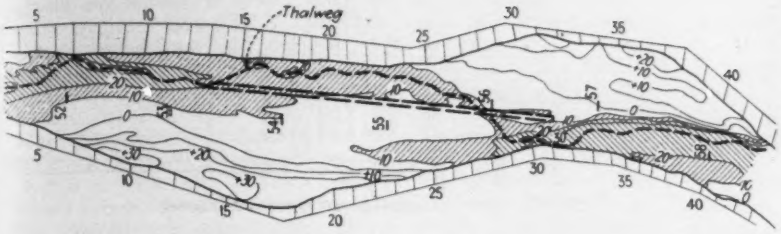


Fig. 3—Stretch of river channel and overbank areas modeled for study of dredge channels at crossing bars. The outside lines show the model limits.

ect goes to the research division, which plans tentatively the experiment, models, procedure, etc., and reports to the director. This tentative plan as approved goes back to the research division, which reports a plan in detail as a subproject to be undertaken and gives a full estimate of work required, time, costs, etc. This report goes for approval to the engineer district or other body desiring the experiment. The detail work then proceeds.

The research section, or that group given charge, prepares plans for the model. These plans go to the model constructor, who builds the model under strict inspection. Experimentation is then begun by the group in charge, using such procedures and observing devices as are required. Instrumental readings and copious notes are recorded. The essential data, results and summaries, with photographs, charts and graphs are then presented as a report. The original records are filed, including diaries, log of tests, photographs and often moving-picture films not in the report.

Model design an expert procedure

The essential processes of model design are: (1) selection of type, (2) selection of model limits, and (3) selection of model scale values. Models may be reduced or full scale, distorted or undistorted scale, and fixed bed or movable bed. Definition is obvious except perhaps of distorted and undistorted models. Physically, the distinction is simple.

An undistorted model is one in which all linear dimensions are on the same reduced scale; the model has exact geometrical similarity to the object in nature (river, channel or harbor) that is being modeled for test. In a distorted model the geometrical similarity is abandoned by making the vertical and the horizontal scales different. The purpose of this distortion is to get similarity of performance of model to prototype. In detail the process of developing model similitude is of some intricacy and cannot be extended here; only the general theory and argument can be stated.

It is impossible in a small model of a river or harbor to simulate in model scale all the natural conditions. Certain acting forces and properties of materials acted upon cannot be reduced to model scale. These properties include density and viscosity of the liquid and the size, shape, cohesion and density of the bed and bank materials. The external forces include gravity, friction, surface tension and barometric pressure. It is obviously impossible to decrease or modify these forces and properties to model scale ratio. In order that they may not become disproportionate, they are kept in harmonious relationship by geometrically distorting the model by increasing the vertical scale. In brief, geometrical similitude is sacrificed to secure similitude of action and effect.

Distortion, as practiced in model experimentation, does not result in misleading phenomena. This would be the case if the model were not distorted. The distortion is solely vertical. Its amount is determined separately for each condition as slope, channel and overbank section and roughness of bed. No distortion of the alignment of the river banks and their variable curvatures is permissible. When these are produced in true relationship, bed effects are unchanged by increasing the vertical scale. This has been proved many times by operating movable bed models from a flat bed until this bed has finally assumed the contours of nature. Comparisons of maps made from nature and model have in 8 and 10 to 1 distortions been so identical as to make it difficult to distinguish between them. Even in distortions of 15 and 20 to 1, qualitative reproductions are obtained.

The procedure in designing distorted models is best understood from a specific example; for this the model of the Mississippi River channel at Island No. 9 is selected. At this point a remedy for bar and crossing formation was being sought. The conditions dictated obviously a reduced-scale distorted model with a movable bed. Critical selection centered then on model-area limits and on model scales.

The critical area of the river to be studied centered about a crossing at about mile 56. As shown in Fig. 3, from about mile 52 the channel to about mile 55 is along the left bank, and a long bar extends out from the right bank. At about mile 56 the right bank bar meets a bar from the left bank, and a crossing is formed through which the channel cuts over to the right bank. As stated, this crossing was the center of study.

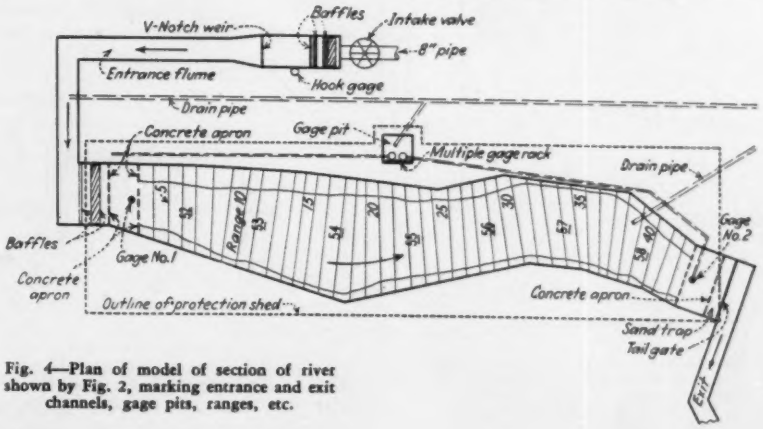


Fig. 4—Plan of model of section of river shown by Fig. 2, marking entrance and exit channels, gage pits, ranges, etc.

The limits of the model were the first consideration. Along the river the model had obviously to extend in each direction from the crossing far enough to stabilize the entrance and exit flow to the conditions of nature. Transversely, the limits were required to be wide enough to include any overbank topography that might tend in high water to govern in any degree movement in the channel of the model river. Study of the river survey maps, which gave the topographic and hydrographic data, and of the gage records, which gave the hydraulic data, indicated the model limits outlined in Fig. 3. Briefly, the modeled length of channel was carried 5 miles up and 3 miles down the river from the crossing. The modeled width included all overbank area flooded at high stages. These limits, the map and gage data indicated, would reproduce natural-flow phenomena in the model.

Determination of the model scales began with the horizontal scale. This, as in most models, was the multiple of a number of factors, as cost, available space, volume of water supply and accuracy and refinement of model determinations required. Practicability in effect determines the horizontal scale, keeping in mind always the test results sought. In this particular case a scale of 1:600 was selected.

In selecting the vertical scale three

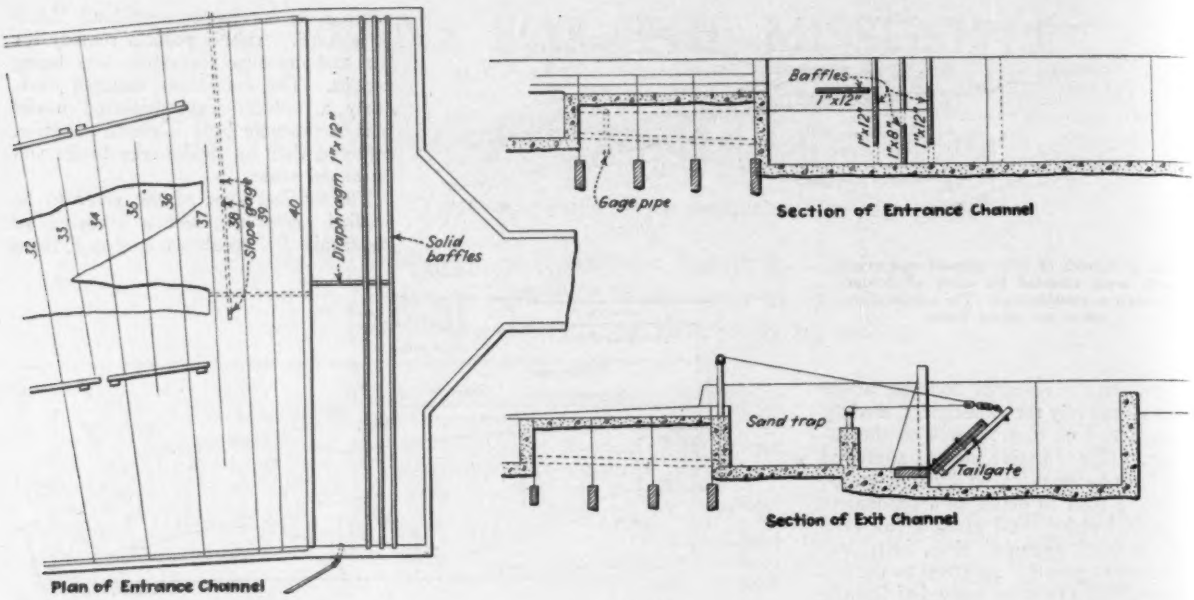


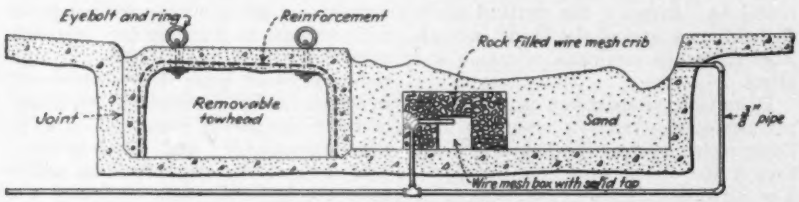
Fig. 5—Details of inlet and outlet devices for a river model constructed at the Vicksburg hydraulic laboratory. Another arrangement is indicated by Fig. 4.

requirements governed: (1) It had to give measurable depths; (2) it must not be so large that the resulting geometrical distortion would produce bank slopes steeper than the angle of repose of the material; and (3) turbulent flow had to be ensured. Based on these requirements, a scale of 1:150 was selected.

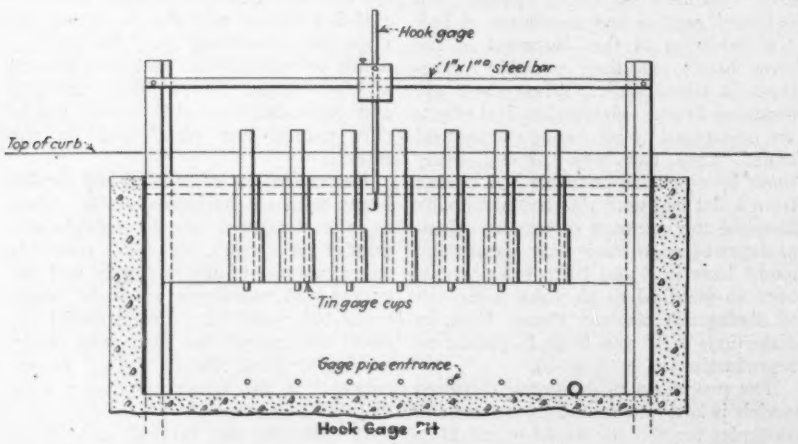
Determination of slope was then as follows: the mean low water slope in nature through this reach of river is 0.00005. Reproducing this slope in the model flow would not give sufficient tractive force to transport the material of the movable bed. Previously the sand for the model bed had been selected with an analysis curve corresponding closely to the analysis curve of sample bed-load sand taken from the river at mile 51. The procedure was then to determine what slope in the model was required to give the required tractive force to produce bed movement. The selected sand was placed in a precisely constructed tilting flume, and water was passed over it at the scale depth at which the transportation of bed material occurred in nature. By accentuating the flume tilt gradually, the slope was determined at which movement began.

The natural slope was 0.00005. The simple distortion of the model increased this slope to 0.0002. The flume tests showed that a slope of 0.0014 was required to move bed load. This additional slope was secured in the model by regulating the weir and the tail gate. With the linear and slope scales determined, the area, velocity and discharge scales were readily computed.

Fig. 6—Details of gage entrance and gage-recording pit typical of practice at the Vicksburg hydraulic laboratory.



Removable Towhead And Gage Entrance



Hook Gage Pit

Model construction is exact

The construction of a model begins with the laying out of ranges across the model site from a map plot of the model. A plan of the specific model being considered is shown by Fig. 4. In this model the ranges were located about 1½ ft. apart in lines about normal to the river. Cross-sections of channel and overbank along these ranges were then plotted to full model scale. These cross-sections were reproduced in male and female templets cut from galvanized sheet steel and stiffened by boards.

Actual molding began by excavating a pit about 1 ft. deep and of sufficient area to hold the model. In this pit the female templets were set accurately to elevation along the range lines and filled between with tamped earth to 1½ in. below their tops. Surfacing was then applied by filling the interspaces with 1:5 cement-sand mortar and toweling it flush with the templet tops. This mortar was accurately molded to line, profile, contour and other topographic features. Gages and gage pit were set up, and entrance and exit canals were constructed as indicated. The sand movable bed was then

placed and molded to shape, using the male templets as guides. The model was protected from rain and sun by a shed.

These are the general lines of model construction. In detail there are many other operations. Various kinds of bed materials are used, brush and trees are simulated, bank and overbank roughnesses are produced and hard spots in the channel are reproduced. Dikes, levees, jetties, breakwaters, dams, locks and other harbor and waterway structures are simulated and often made movable so that effects of position and location can be determined. Tributary streams are modeled and provided with independent flow. A model at the Vicksburg laboratory is in short not a rough reproduction in any essential particular, it is a recreation in miniature of the natural river or harbor as far as effect on hydraulic action and phenomena are affected.

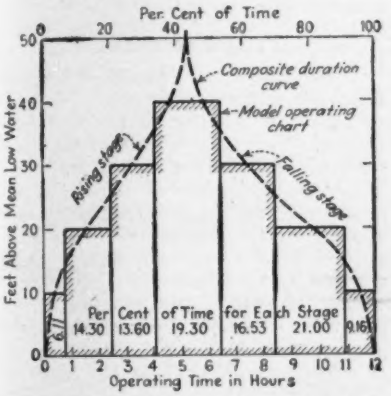


Fig. 7—Operating chart for a model based on hydrographs of river ranging over a five-year period.

Model appurtenances are simple

The appurtenances for controlling, observing and recording model action are kept simple. Of the first importance are the water inlet and outlet devices, two examples of which are shown by Figs. 4 and 5. Generally the inlet is a V-notch weir that discharges into a stilling reservoir and approach channel to bring the water to the condition of flow required in the test. The outlet is generally a gate capable of adjustment vertically so as to control, in connection with the inlet weir, the water stages desired.

Water stages are measured usually by hook gages, but manometer devices have been used in many of the experiments. The exceptional feature of the arrangement (Fig. 6) is the grouping of the registering elements in batteries connected by under-surface pipes to the gages spotted, as desired in the bed of the model. Both the bed gages and the hook-gage pit are shown by Fig. 6. The feature of the gage pit is the arrangement by which one hook gage serves a battery of gage cups. In general, the arrangement for manometer measurement is identical.

For recording bed profiles in movable-bed tests, a scaled bar is spanned across the model and, working from a bridge, the recorder reads the elevations, working along the span with a vertical rod having a scale for direct reading. This has been found faster and more accurate than any form of tracing profilometer that has been tried. Other devices include meters, piezometers, pitot tubes, and various materials such as strings, celluloid floats, dyes and oats for showing current direction, bottom drag, bar formation, etc. Special apparatus has included devices for creating ebb and rise of tide and surf breaking on a beach.

Model operation

Model operation differs for each model and with the purposes of the experiment. Procedure with the model shown in Fig. 4 indicates characteristic practice. First, a composite duration curve was prepared that represented the average rising and falling stages of the river and the per cent of time for each stage for the years 1925 to 1930. From this curve a simplified model-operating chart was prepared, as shown by Fig. 7. By simulating the stages, as indicated on this chart, the model was made to pass through a cycle representing a normal sequence of conditions in nature. A gage-relation curve was plotted, based on the same gage that was used in the operating chart. This was used for establishing gage heights in the model. With these controls established, model test runs were made.

The model was first given a calibrating run through a complete cycle, with the bed molded to the surveyed profiles and sections. The model was then cross-sectioned and a contour map plotted and compared with the similar map from nature. The comparison showed the bed to be generally representative of its prototype. The bed was then molded flat and the model run through another cycle. Cross-sections showed the sand to have taken the formation shown by the first run. With this proof of similarity of action, the schedule of test runs was put through.

As indicated previously, the tests are carried through hydrographs compiled from flow-duration curves of the stream in nature and covering as many years as are necessary to indicate normal ranges. The laboratory has determined a twelve-hour hydrograph to give excellent results; incidentally this is about a third longer than is common practice. This means that in twelve hours the model is subject to all the stages of the natural river and is held at each stage a period of time proportional to the length of time that a stage exists in nature as determined from the stream hydrographs.

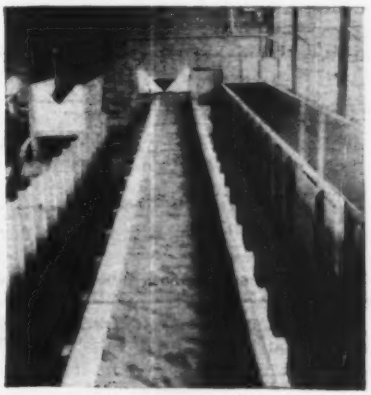


Fig. 8—Flume for determining slope at which flow will move bed material used in a model.

SUMMARY OF INVESTIGATIONS AND MODEL EXPERIMENTS CONDUCTED AT VICKSBURG HYDRAULIC LABORATORY

1. Determination of backwater effects in *(a)* Illinois River l = 1:1200, d = 1:48; *(b)* Red River l = 800, d = 1:80.
2. Determination of damage to railroad embankments by overflowing floodwaters and effects of downstream sills in preventing such damages. (Four undistorted models as follows: 1 = 1:1, = 1:5, = 1:10 and = 1:20.)
3. Sediment investigations. (Field samples taken and analysed in laboratory.)
4. Effects of operation of Bonnet Carré floodway. (l = 1:100, d = 1:100.)
5. Erosion tests of materials in Bonnet Carré floodway, Atchafalaya and Boeuf Basins.
6. Development of proposed pilot channel in Boeuf Basin. (l = 1:10,000, d = 1:100.)
7. Dike and contraction studies at: *(a)* Walkers Bar, Ohio River, l = 1:720, d = 1:72; *(b)* Morrison Towhead, Mississippi River, l = 1:700, d = 1:72; *(c)* Stewarts Bar, Mississippi River, l = 1:1000; *(d)* Raleigh Bar, Ohio River, l = 1:700, d = 1:70; *(e)* Island A, Mississippi River, l = 1:500, d = 1:125; *(f)* Island 35, Mississippi River, l = 1:600, d = 1:150; *(g)* Racetrack Towhead, Mississippi River, l = 1:1000, d = 1:100; *(h)* Ft. Charles U., Mississippi River, l = 1:1000, d = 1:100; and *(i)* Brooks Point U., Mississippi River, l = 1:1000, d = 1:100.
8. Lock and dam studies as: *(a)* No. 37, Ohio River, models, l = 1:300, d = 1:60; and l = 1:120, d = 1:120; *(b)* Starved Rock, Illinois River, l = 1:170, d = 1:35.
9. St. Lucie Canal Spillways, Lake Okeechobee drainage project. (Two undistorted models scale 1:10.)
10. Cutoff studies, Mississippi River. (Two models: l = 1:4800, d = 1:360; and l = 1:2400, d = 1:120.)
11. Movement of bed in bifurcating flumes.
12. Miscellaneous revetment tests.
13. Movement of bedmaterial in Mississippi River combined with studies of tractive force required to produce bed movement (special flumes).
14. Levee seepage tests. (Undistorted model 10 ft. high built as an experimental loop.)
15. Effects of levee extension south of Eagle Lake, Mississippi River. (l = 1:2400, d = 1:120.)
16. Effects of operating the Birds Point-New Madrid Floodway. (l = 1:4800, d = 1:200.)
17. Effects of sills in St. Clair River. (l = 1:100, d = 1:100 and 1:50.) Also theoretical flume tests to determine effects of submerged weirs.
18. Effects of water and silt diversions from Mississippi River.
19. Miscellaneous control tests and experiments of more or less experimental nature.

Many New Specifications Adopted at A.S.T.M. Meeting

Committee activities and research work prove as stimulating and complete as ever—Cast-iron, brick masonry, steel, wrought-iron and road materials receive major consideration in first three days of convention at Chicago

Engineering News-Record Staff Report

EXCESSIVE HEAT and the Century of Progress Exposition combined to reduce attendance at some of the sessions of the 26th annual convention of the American Society for Testing Materials in Chicago, June 26-30, but did not affect adversely the useful work that the society transacts each year. Specification changes were as numerous as ever, reflecting conscientious committee work, and the papers delivered were in general of a stimulating character, giving an indication that research has continued unabated, in quality if not in quantity, during the depression. A registration of about 700 was recorded, which is about two thirds of normal.

Many new research results and studies contributing to knowledge in the field of materials were reported in technical papers. Prominent among them were data on brittleness of heat-treated steel cable wire as revealed by tension tests under pulsating stress (Mount Hope Bridge wire study); a proposed method for quick determination of fatigue or endurance limit (Moore and Wishart's "overnight test"); a discussion of the factors of permeability of brick walls; comprehensive data on the physical properties of American bricks; study of the effect on cement of adding siliceous material; a surface-area fineness method for cement; a study of cement specifications; and a symposium of opinion on the significance of concrete and aggregate tests.

Several groups of semi-scientific papers and addresses in the economic field further individualized the meeting. Spectrographic problems were the theme of one group; of another group, methods applicable to experimental data and to inspection. Two sessions of the Econometric Society with a group of engineering societies dealt with mathematics of observation and economics, and with broad aspects of the contact between engineering and social, economic and political questions.

The accomplishments of the meeting in so far as specifications work was concerned are expressed by the following statistics, which are not entirely complete: New tentative standards, 26 material specifications and 10 methods of test; new standards, 39 specifications and 19 methods; revisions were made in 29 specifications and 22 methods; 22 standard specifications and 3 standard methods of test were withdrawn.

In so far as general activities are concerned, the Charles B. Dudley medal was awarded to Samuel Epstein, metallurgist, Battelle Memorial Institute, for his paper of last year on "Embrittlement of Hot-Galvanized Structural Steel." The Edgar Marburg lecture was given by Herbert J. Gough of the National Physical Laboratory of England. T. R. Lawson, head of the department of civil engineering at Rensselaer Polytechnic Institute, was elected president. W. H. Basset, American Brass Co., was made senior vice-president, and Hermann von Schrenk, consulting engineer, St. Louis, was made second vice-president.

Under the title "Introspection," the presidential address of retiring president Cloyd M. Chapman presented a thoughtful survey of the society considered as a specialized machine for producing joint-use specifications to express and harmonize the needs of user and producer of material, a machine that now supplies some 50 fields of use. He demanded that the machine be kept in condition to produce an output of high quality with adequate rapidity, that it be adaptable to changing market demand, and that it be efficient.

Phenomena of rupture

A notable event of the meeting was the Marburg Lecture, delivered by Dr. Herbert J. Gough, superintendent of the engineering division of the National Physical Laboratory, Teddington, England, on the subject "Crystalline Structure in Relation to Failure of Metals Especially by Fatigue." Dr. Gough opened by saying that a multitude of modern problems, such as construction of engines and hulls of all-metal airplanes, makes precise understanding of failure conditions of metals essential. Until the advent of X-ray analysis and the production and study of large single crystals of metal, however, it had not been possible to obtain any real information on the conditions of break-up. It is now known that slip always precedes rupture of metals.

Crystal study by X-ray spectrography shows that slip occurs along one of those crystal planes on which the atoms are most numerous; of the several planes of this kind, it selects the plane having the largest tangential shear component. The work-hardening that tends to limit slip may best be explained by the action of the slip to distort the shell or fog of electrons which surrounds the atomic nucleus. Repetition of slip ultimately causes cracks to start; these, Dr. Gough suggested, may be caused by the misalignment of small crystal units through slip, which leads to a stress concentration and so to the initiation of a crack capable of spreading under stress repetition. In order to extend these deductions from single crystals to ordinary metals, which are crystal aggregates, experiments have been made on aggregates of a very few crystals. It was found that the crystal boundaries do not stop the slip, which passes from crystal to crystal along the most nearly aligned plane of slip weakness. Crystal boundaries, however, do check the progression of a crack.

Fatigue of metals

Three papers were presented bearing upon the important subject of fatigue of metals, in addition to Dr. Grough's lecture. The most important was one by Prof. H. F. Moore and H. B. Wishart, of the University of Illinois, on an accelerated fatigue test, called by the authors an "overnight test" to distinguish it from "short-time tests," which are said to have been uniformly unsuccessful. In making the test five or six specimens of known Rockwell hardness are subjected to about 1,400,000 cycles of stress (requiring about 15½ hours at 1,500 r.p.m.) in rotating-beam machines. Upon their removal from the machines the ultimate tensile strengths of the specimens are determined. Then, making corrections proportional to the Rockwell hardness, the data are plotted with stress applied for a period of 1,400,000 cycles as ordinates and tensile strength after this period as abscissas. The endurance limit is taken as the ordinate corresponding to the maximum abscissa of this curve. Checked against long-time fatigue tests for numerous metals the method showed a maximum variation less than 12 per cent. The greatest discrepancies occurred with duralumin. The theory of the overnight test is that below the endurance limit repeated flexure increases the tensile strength by cold work, while above the endurance limit cracks develop that reduce the tensile strength.

The fatigue properties of light metals and alloys were discussed in a paper by R. L. Templin. No satisfactory short-time fatigue test has been developed. The elaborate fatigue-testing equipment in the Aluminum Company laboratories was described. Usually 500,000,000 cycles of stress are used. Several of the diagrams shown indicate that very unreliable values for endurance limits would be obtained in short-time tests.

The third paper on fatigue, by S. M. Shelton and W. H. Swanger (Bureau of Standards), discussed tests of heat-treated galvanized wire under pulsating tensile stress. This type of test is held more indicative of service condi-

tions for wire than is the rotating-beam test. Results on the same wire under the rotating-beam test, reported two years ago, gave a 52,000 lb. per sq. in. fatigue limit for unmachined specimens and a 110,000-lb limit for standard machined specimens Standard machined specimens of cold-drawn wire of the same carbon content and ultimate strength showed a limit of 118,000 lb. In the new tests reported the limiting range of pulsating tensile stress was determined at various mean tensile stresses from 50,000 to 150,000 lb. for both the heat-treated wire and similar cold-drawn wire. The average limiting range of pulsating stress over the whole series of mean stresses was 49,000 lb. per sq. in. for both types of wire.

An important paper in the field of fatigue was presented before the American Society of Mechanical Engineers, which met in Chicago at the same time and partly in joint session with the American Society for Testing Materials. It was "Influence of Corrosion Pits on Fatigue," by D. J. McAdam, Jr. (Bureau of Standards) and R. W. Clyne (American Steel Foundries). The authors contrasted the effect of chemically formed and mechanically formed notches upon fatigue resistance, and indicated that work-hardening during the shaping of the notch influences the effect of the latter. The roughness of the notch also may increase its damaging effect. Their discussion was extended to threads, keyways and fillets.

Steel and wrought iron

Specification work in the field of steel included slight revision of the specifications for building and bridge steel (to cover rolled baseplates, 0.15 to 0.30 carbon for structural grade, 0.20 to 0.35 carbon for medium grade); cold-drawn wire reinforcement (to include minimum yield-point, 0.80 of ultimate strength); and open-hearth welded and seamless pipe (reducing the elongation from 40 to 30 per cent). A new specification for alloy-steel structural castings was presented, covering heat treatment and strength but not composition. Tentative specifications for rivet steel, ship steel and track parts were advanced to standard. Further, the change introduced tentatively a year ago in all specifications that allow bessemer steel, to limit this term to acid bessemer, was advanced to standard.

With the adoption of the rivet steel specification the rivet clauses in the bridge, building and car steel specifications will be deleted. The steel committee has begun a study looking toward combining all its rivet specifications; this is part of a broader movement to reduce the number of specifications by consolidating those covering similar materials for similar uses.

A list of the steel specifications that can be used for fusion-welding material was also presented. By an unusual procedure, two new specifications were presented for adoption though they had not been read even by members of the committee in charge; these cover high-tensile carbon steel plates for pressure vessels, such as penstocks, in thicknesses under 2 in. and from 2 to 4 in.

Wrought-iron rivets, required because of growing demand for iron tanks and pipes, are covered by a new specification (manganese 0.05 per cent max., tensile strength 47,000, yield-point 0.6, elongation 28 and 24 per cent in 8 in. for sizes up to and above ¾ in., quenched bend 90 deg. on 1-diameter radius, hot bend 180 deg. flat, head flattened hot to twice shank diameter, etching test for fiber distortion at head). Welded pipe specifications were revised by adding a manganese limit (0.05 per cent). The Wrought Iron Committee is engaged in preparing a monograph on quality standards for wrought iron.

It was reported that pipe dimension standards covering the full range of piping work in iron and steel—for all pressures and temperatures, of wrought-iron, carbon steel or alloy steel, and for various processes of manufacture and types of end connection—have been prepared by a sectional committee of the American Standards Association and may shortly be adopted. These standards are to be used with nine separate A.S.T.M. pipe specifications.

After working four or five years since its last previous report the research committee on effect of sulphur and phosphorus in steel summarized its recent work. Tests on forgings showed little effect of sulphur; low-carbon (rivet or pipe) steel showed some effects due to phosphorus but no characteristic influence; impact strength was found to be irregular, but this was believed changeable to other variables.

Shear and Poisson Ratio of Steel—Tests by Prof. Inge Lyse and A. J. Godfrey (Lehigh University) showed the following results for shear strength and Poisson ratio of steels: slotted plates in tension and cylinders in torsion gave similar shear strength and yield-point values; the shear yield-point was generally below 0.60 of ultimate tensile strength for structural grade, 0.66 to 0.81 for quenched and drawn alloy steels, and 0.77 to 0.89 for annealed alloy steels. The Poisson ratio ranged from 0.27 to 0.31 for both grades. The yield-point of lateral stress occurred at the same load as the longitudinal yield-point and was equally sharp.

Toughness of Tool Steel—By use of a specially devised impact test in torsion, G. V. Luerssen and O. V. Greene (Carpenter Steel Co., Reading) found that certain quenched and tempered carbon, chrome and other alloy steels show a large maximum of toughness in a narrow range of drawing temperature (at 375 deg. F. for carbon steel, 350 F. for chrome ball steel, 900 F. for high-speed steel), a result revealed neither by ordinary impact tests, notched or unnotched, nor by hardness tests. Similar toughness relations were observed by A. F. Davis (Waterbury) in the case of gun shields, which shattered at low draws.

Cast iron

A symposium on cast iron, occupying a complete session of the meeting, marked the continuance of a program inaugurated in 1930 to provide the engineering profession with authoritative and modern data on the properties of metal castings. Malleable castings were covered in 1931, steel castings in 1932 and cast iron this year. The data presented were abstracted from a 140-page mimeographed report. They can only be touched upon briefly here. The most immediate practical information for the user of cast iron was given in the section on properties, presented by J. T. MacKenzie (American Cast Iron Pipe Co.). Other sections covered metallurgy, classification and specifications, heat treatment, white and chilled irons, welding and a group of detailed recommendations to designers of iron castings. The following data are from the part of the symposium reported by Mr. MacKenzie.

Tensile strength is regarded as the most important property of cast iron. For gray iron, characterized by a predominance of free carbon or graphitic carbon, tensile strength is clearly controllable between 20,000 and 60,000 lb. per sq. in. Compressive strengths are 3 to 5 times tensile strengths. Transverse modulus of rupture is much higher than tensile strength. There is no defined elastic limit, but the effective modulus at 25 per cent of the ultimate load (working range) is from 12,000,000 to 18,000,000. Shear is from 1.0 to 1.6 times the tensile strength, ranging from 25,000 to 80,000 lb. per sq. in. The endurance limit varies from 42 to 57 per cent of the tensile strength depending on the type of iron. For gray irons it is between 9,000 and 26,000 lb. per sq. in.

As between different cast irons there are wide differences in impact strength, which depends largely on the form and quantity of the graphite present. Hardness obtainable varies from slightly over 100 Brinell for fully annealed iron to about 450 for ordinary chilled irons and up to 700 for special chilled and heat-treated irons. Cast irons respond quite as readily to heat treatment as do steels. One of the important modern developments in cast iron is the control of carbon content.

The corrosion resistance of cast iron is high, but there are conditions to be guarded against. Dilute sulphuric acid attacks gray iron severely, and so does nitric acid. Alloys of iron using chromium or silicon are proving effective to combat these acids. Copper, chromium and nickel (if in combination with chromium) increase the corrosion resistance of cast iron.

E. R. Smith reported an interesting procedure for welding cast iron. A number of holes are drilled in the cast-

ing each side of the location of the proposed weld. These holes are plugged with steel studs. Thus when the weld cools, the residual strains are taken by these steel studs, eliminating cracking of the iron. Welding in general has been used only to repair cast iron and not in the manufacture of iron castings.

Committee A-3 on cast iron reported on its investigation of impact testing, said to be the most important work ever undertaken by the committee. Mr. MacKenzie had charge of this work and reported on it also. Impact tests of cast iron vary considerably, and the investigation sought some sort of correlation by testing some 25 cast irons of a large range of compositions and melting methods. Small-bar specimens were shown to be unsatisfactory. Larger bars (1.20 in. in diameter) gave better results. Falling-hammer tests promise good possibilities. The investigation brought out no definite relationship between shock resistance and tensile or transverse strength except that all three increase together. No specification was recommended.

Two other investigations were reported as completed—the trench loading on pipe at Iowa State College and the bursting pressure tests of pipe at the University of Illinois. For a full length of pipe, bursting pressures of the order of 15,000 lb. per sq. in. were obtained. These are about one-half those usually obtained on short specimen lengths of pipe.

(The remainder of the convention report will appear in the July 13 issue.)

Civil Engineers Join in Engineering Week

Meeting marked by strong technical activity, numerous inter-society sessions, and attention to economics and professional development—St. Lawrence project leads to acrimonious controversy

Engineering News-Record Staff Report

AS ONE of the dozen or more technical societies that met in Chicago during the Century of Progress exposition's "Engineering Week," the American Society of Civil Engineers held its summer meeting under conditions rather unfavorable to a serious program. Yet the convention easily ranks as the society's strongest summer meeting of recent years, both in interest and in the importance of the work done. If anything could be said to have marred it, it was an acrimonious controversy that arose during discussion of the St. Lawrence River development project, though the paper of Daniel W. Mead under discussion was undoubtedly the technical high spot of the meeting.

Unfavorable factors included a congested meeting schedule (there were nineteen technical sessions in three days, aside from evening lectures and noonday addresses), direct competition for the attention of members by the meetings of such bodies as the American Society for Testing Materials and the Society for the Promotion of Engineering Education, in both of which many A.S.C.E. members take an active part, and the attraction of the exposition. Extraordinarily sultry weather was a further discouragement. Despite these conditions the attendance (some 1,300) was nearly double that of the average summer meeting, and most of the technical sessions drew crowded gatherings. Several inter-society general sessions and celebrations, among them the bestowal of the Guggenheim award for aeronautical achievement to Juan de la Cierva in a formal assembly in the lakeside stadium, and the conferring of the Henry L. Gantt award to H. F. Dennison in an evening session of economic addresses, gave the meeting additional breadth of interest.

Action by board of direction

Outstanding among the matters acted on by the board of direction at its meeting held in advance of the Chicago convention were the development of the engineering profession and the protection of its interests. The board ratified the charter and rules of procedure of the Engineers' Council for Professional Development, an inter-society body that is to concern itself with such matters as vocational guidance and the education of engineers, their post-graduate training and induction into the professional body. Several years of discussion and planning find their fruition in this action. Similar ratification has been accorded by the mechanical and chemical engineers, and several other professional bodies are about to take like action.

Basing their recommendations on a report of the committee on salaries, the board adopted a scale of maximum permissible temporary reductions in the salaries of employed engineers, according to 1930 salary levels, the scale to apply to the date of July 1, 1933. These reductions range from approximately 10 per cent for $1,000 to 15.6 per cent for $5,000, the upper level of a 1930 salary to which the adopted scale applies.

Consideration was given to certain present undesirable conditions surrounding engineering work in the conservation camps, and the board initiated efforts to bring about correction of these conditions in respect to the work of engineers.

In view of financial conditions the board made further reductions in the society's budget and took steps to assist in meeting the problem of members of long standing who have found it impossible to continue payment of dues. The proposed fall meeting at Phoenix was cancelled.

In addition to numerous other administrative actions, the board named A. J. Hammond a member of the John Fritz Medal board of award, authorized the formation of student chapters at South Dakota State College and Lewis Institute, considered several cases of alleged unprofessional conduct and questions of ethical practice, and recognized with appreciation the completion of the work of the special committee on steel column research, which committee received its discharge.

Other resolutions of the board included one favoring a thirteen-month calendar.

Economic relations

From these notes on the proceedings of the board of direction it will be seen that professional relations and development received unusual attention.

In a broader sense the same kind of thought and the related theme of the engineer's relation to economic progress were given marked emphasis by several of the general sessions. A leading factor in this emphasis were two remarkable addresses at the midweek joint engineering dinner, by E. J. Mehren on "The Contribution of Engineering to Progress," and by Karl E. Compton on "A Century of Progress: What Next?" Others were addresses before a joint meeting of engineering organizations with the Econometric Society, by A. P. Fleming, of Manchester, England, on "The Internationalization of Scientific Knowledge as a Factor in World Economic Recovery," which in part was a thoughtful reference to the system of industrial development being carried out by the Soviet Republics, and by F. B. Jewett on "Some Fundamental Problems of the Engineer," who said that the engineer's greatest tasks today are concerned with finding ways of assuring adequate social and political controls. Of related import was an address by General Lytle Brown, Chief of Engineers, U. S. Army, at a luncheon sponsored by the Society of American Military Engineers, which directed attention to the essential function of the civilian

engineering body in national defense in war emergencies.

Aiming to include in its Chicago meeting a discussion of the outstanding power question of the day, the Power Division last winter decided on a discussion of the several schemes for developing the international section of the St. Lawrence River that have been under consideration for more than a dozen years. A leading motive for the decision, no doubt, was the fact that the treaty agreed upon last year between the United States and Canada, not yet ratified, was based on a two-dam scheme instead of the single-dam schemes that had previously been held to be more economical. The committee of the division therefore sought to obtain a competent, disinterested review of the several schemes (previously set out in elaborate official reports) in respect to their efficiency and economy. Prof. Daniel W. Mead, of the University of Wisconsin, was chosen to make this review.

Mead's St. Lawrence paper

Prof. Mead's findings were presented by him in a paper that included detailed figures of power output, first cost and operating cost, taken from the official reports and in part corrected by him for discrepancies between the several reports. He pointed out that since the Wooten-Bowden report of 1921 the American engineers have consistently advocated a single-stage plan and the Canadian engineers have consistently advocated a two-stage plan. The Joint Board, reconvened in December, 1931, was later instructed to reach an agreement on a plan for early execution that would provide effectively for navigation and power. Prof. Mead indicated that these instructions necessitated coming to a conclusion that would not involve either the best or the most economical development.

Prof. Mead compared the treaty two-stage plan (dams at Crysler Island and Barnhart Island), the single-stage Barnhart Island plan, and the single-stage Massena Point or New York Commission plan. He found that the two-stage plan is "deficient in output and therefore in earning capacity and more expensive in cost of operation." The prior reports show the development costs to be $274,742,000 and $236,418,000 for the first two plans (international reports) and $204,225,000 for the third (New York Commission report), considering both power and navigation works. In further analysis, however, Prof. Mead calculated much larger cost differences if capitalized values of income and operating expense are income and if certain errors are corrected. He concluded that,

> "If the reports and estimates considered are correct, there can be no question that the single-stage Barnhart Island plan is at least $70,000,000 greater in value than the two-stage Crysler Island plan, and that the single-stage New York Massena Point plan exceeds the two-stage plan in value by at least $140,000,000.
>
> "The New York plan, which apparently received no consideration by the Joint Board, seems to be not only much less expensive in first cost but also much less hazardous in construction and to be an improvement from a navigation standpoint by eliminating one lock and greatly reducing the necessary length of canal.
>
> "The author can see no valid reason to justify the two-stage plan which can outweigh the millions of dollars of value in favor of other plans. If the reports are in error or the reasons for advising the two-stage plan cannot be made manifest the author believes this project should be further and completely investigated before the United States and Canada are asked to make the great permanent investment involved by this project."

In his own synopsis he said even more specifically: "It will be a very serious mistake and a misfortune to both the United States and Canada if the treaty now pending is ratified on the basis of the Joint Board Reconvened report."

After presenting his paper, Prof. Mead made militant reply to a circular letter that had been sent to officials of the societies by the New York Power Authority, attacking the paper as propaganda.

Thomas H. Hogg, chief engineer of the Hydroelectric Power Commission of Ontario, discussed the paper in great detail, taking issue with some of the author's technical and cost interpretations, greatly reducing the cost differences found in the paper, and declaring the Massena Point scheme to be the more hazardous. However, he said, the choice of schemes cannot be settled on economic or engineering considerations alone. Land takings and flood risks enter, and because of them public opinion in Canada was built up in favor of a two-stage plan and against a sing'e-stage plan. The treaty plan "all things considered, represents the best solution of the problem," Mr. Hogg said.

Mead report attacked

Frank P. Walsh, chairman of the New York Power Authority, who had sent out the circular letter mentioned by Prof. Mead, now presented his protest in person. In character it was a bitter personal attack on Prof. Mead and the officials of the Power Division. Mr. Walsh denounced the paper as propaganda, and asserted that its propaganda purpose was emphasized by an abstract that had been prepared for the convenience of the meeting by L. J. Bevan, chairman of the division; he charged that J. W. Rickey, chief hydraulic engineer of the Aluminum Company of America (which has a power plant at Massena), was put on the division's executive committee directly after the New York Power Authority was appointed, and through his manner of making the charge he implied that Mr. Rickey's election was an act hostile to the Power Authority and the public interest and favorable to the interests of the company. However, he admitted that the Power Authority favors the single-stage plan of development, but realizes that it means ten years' delay, which, he stated, would cause a loss of $100,000,000 to the people. Finally, he read a letter from a member of the Foreign Relations committee of the U. S. Senate, which attacked the integrity and disinteredness of Prof. Mead in even more vitriolic style than he himself had done.

Col. E. M. Markham, member of the Joint Board Reconvened which arrived at the treaty project of April, 1932, explained the board's action by saying that the United States could not expect to accomplish a solution that would not obtain Canadian consent, and that the board reported a two-stage plan "since no one-stage plan could be agreed upon"; also that "for a variety of reasons the Massena Point plan was not acceptable to the Canadian members." Earlier boards, he said, had sat and sat and sat, but could not reach agreement on purely engineering grounds. The recommendation of the Joint Board Reconvened was an "international compromise."

Frederick Stuart Greene, member of the New York board that preceded the New York Power Authority and drew up the Massena Point plan, stated in a letter read by Mr. Bevan that he could not conceive how either the United States or Canada can possibly stand for any plan that would produce less power for more money. Frank T. Williams, secretary of the New York Water Power and Control Commission, in another letter said that the cofferdam hazard of the two-stage and Barnhart Island schemes should receive full consideration, and that the Massena Point scheme has lower cost, more power, shorter construction time and less hazard than any other. He stated that the New York board, whose findings Mr. Walsh had called insufficiently considered, comprised General Edgar Jadwin, O. G. Thurlow, Silas Woodard, and Frederick Stuart Greene.

William S. Lee cautioned the society against getting into a tangle of controversy and accusation. L. F. Harza, former student and collaborator of Prof. Mead, protested strongly against the Walsh insinuations of dishonesty, bias or self-interest, on the part of Prof. Mead. Mr. Rickey, after making reply to the Walsh allegations concerning himself, declared that the prime consideration in the case is cheap power for the people, and that the unit cost of $66 at Massena Point against $99 at Crysler Island is the significant figure of the case. He hoped that the discussion would succeed in putting all cards on the table and bring out how the joint board arrived at its conclusion.

(The remainder of the convention report will appear in the July 13 issue.)

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A Historic Week

ALL WHO attended the technical conventions of Chicago's Engineering Week are likely to agree with Gen. Lytle Brown's terse characterization of the occasion as "one of the greatest meetings of engineers that the world has ever known." Even the most active engineering meetings of pre-war or post-war days did not approach it in caliber. But even beyond its technical strength Engineering Week distinguished itself by inter-society cooperation and attention to new themes—themes of the future, centering around the intimate relation of engineers to economic and social problems. It was a remarkable expression of that broadened thinking of engineers that the last few years has produced. This entry into the economic field was helped by the coming together of different societies in joint meetings. One of the notable meetings of this kind was the closing session, when Frank B. Jewett pointed to the engineer's coming problems in connection with bringing about adequate social and political controls. At the same meeting H. S. Dennison, speaking in the spirit of Henry L. Gantt, whose memorial award he had just received, made the suggestive statement that government partnership with industry will come as soon as men learn that it must come; and that some time also we will learn that *government is management*. It seems clear in the light of the events of Engineering Week that the cooperation toward which engineering societies have been trending in recent years may find new opportunities.

Timely Scrutiny

IN ARRANGING for a comparison and review of the economics of the chief St. Lawrence River improvement projects and in persuading Daniel W. Mead to undertake such review, the cooperating groups of the civil, mechanical and electrical engineers that discussed this subject at Chicago last week performed a useful and timely public service. They brought out of the obscuring fog of bulky reports, partisanship and political negotiation certain vital facts about an undertaking whose business aspects concern every citizen. It had been known that there were large differences between the three principal schemes discussed during the long years of study of the project, but how do these schemes compare in engineering and economic value? This was the question put before Professor Mead, who was chosen as the hydraulic engineer best fitted for the study. Mandates such as he received are not common in the history of the American Society of Civil Engineers, but the wisdom of the procedure in this case is plain. The result fully confirms the expectation that scrutiny of the competing schemes would be timely, for Professor Mead's analysis and conclusions brought to light facts that reach deeply into the pockets of the citizen. His presentation makes a clear case for more adequate explanation of what Colonel Markham frankly termed an international compromise.

Improper and Destructive

THE public importance of the St. Lawrence problem makes especially regrettable the amazing impropriety of Frank P. Walsh's tirade of invective and insinuation against Professor Mead and against the governing committee of the power division. Mr. Walsh is a politician and not an engineer, and politicians are not usually admitted to participation in engineering discussions. Under the circumstances even a politician might be expected to recognize that such an outburst is in execrably bad taste, besides being ineffective. An engineering society meeting is preeminently not the place for personal recriminations or charges, as they lack all power to convince or persuade. If there were no other reasons for the rigid rule against personalities in engineering meetings, this one would be enough, and it is unfortunate that the rule was not observed in the St. Lawrence discussion. The destructive effect of the society's lack of vigilance became apparent at once, when technical discussion ceased completely after the Walsh attack. Yet the very extremity of the bad taste and sensationalism of the occurrence may give it some small amount of constructive value, by helping to bring the treaty obscurities out into the light.

Undiminished Activity

DESPITE a reduction in membership and income of nearly 15 per cent over the past two or three years, the American Society for Testing Materials has suffered no drop in output, either in quantity or quality. This is particularly commendable because the A.S.T.M. is a producing type of organization; its success is measured in tangible output rather than in intangible service, so that lack of financial support or continuous hard work on the part of the members shows up very plainly. The record that A.S.T.M. has made, as evidenced by developments and changes in many scores of specifications and test methods during the past year, is of paramount significance to industry and engineering development. The society is in effect a builder of guideposts, and during the depression, when these guideposts were used less extensively, it has never ceased to keep them in repair. In addition, it has built some new ones, that progress may not be handicapped when industry's shackles are removed. The output of A.S.T.M. is indispensable, and improving business should soon justify the toil of the past year.

Industry Also Progresses

LAST WEEK was significant for something quite different from the technical doings of Engineering Week: concrete progress in the development of effective construction-practice codes in preparation for presenting them to the industry administrators at Washington. This is an event of lasting importance regardless of how long industry control remains in force or even of whether it goes into effect at all. The law has caused every branch of construction to think about its misadjustments, internal and external, in a way it has never done before, and the outcome of such thinking and effort to readjust will be of permanent benefit to everyone, the public in-

cluded. The success in cooperative effort, we think, may in some measure be considered the fruit of the seed sown by the Detroit conferences last January, for it seems that the speed of progress made is far greater than would have been possible but for the mutual approach of construction groups that took place there.

A Progressive Step

THE PRECAUTIONS taken to protect cement used in Madden Dam predict improvements that modern handling methods may introduce into the use of this moisture-sensitive material. Compressed air as an element of recent conveying processes brings cement into rather close contact with whatever moisture the air may contain. The degree of danger depends of course on atmospheric conditions. Under those that are prevailing at Panama the danger may easily be critical. With any except desert-atmosphere conditions, some hazard of cement deterioration exists in handling and job storage. A saturated tropical atmosphere, as experience has demonstrated, is quickly destructive of cement quality. The simple but effective measures of dewatering the air employed in moving cement at Madden Dam, as described in this issue, carry the technique of concrete control a step farther toward precision and safety.

Our Real Progress

HOW GREATLY the world has progressed and how fundamentally engineering achievement has contributed to its progress was appraised with remarkable truth and insight by Edward J. Mehren in an address that deeply impressed all hearers at the joint engineering society last Wednesday evening during the Chicago conventions. His exposition of what the labor and ingenuity of engineers have done for mankind is helpful as a conclusive answer to the oft-heard discouraged and discouraging talk about the vainness of our material advance. Technical and scientific progress has done away with so much toil and pain that its benefits to humanity outweigh all other contributions since the age of darkness.

More remains to be achieved. Our present disorganization gives evidence of the burdens of labor, care and fear that still remain to be lifted from the shoulders and hearts of man. There can be no doubt that engineering will contribute to the coming progress as it has to that of the past; it should aid in freeing men from economic disability as it has helped against physical disabilities. Karl E. Compton well said, in his brilliant supplement to the address noted, that the tremendous job yet to be done, arising from the engineer's work, offers splendid opportunity to the engineer to undertake this job, and that technological education in consequence will see much further growth.

It is hardly necessary to add that engineers will not work alone in dealing with these present and coming problems, and that if they do work alone they can hope for only modest success. Economist, financial, businessman and civic leader must do their part in harmony with the engineer. If these men, as we are sometimes led to believe, move too slowly in performing their allotted share of the work, perhaps the engineer may need to enter into their work in order that he may urge them forward. The beginnings of thought and activity in this direction are already visible.

The Public-Works Program

MUCH has happened in the three weeks since the Recovery Act was passed, only to have its great public-works re-employment program deferred a few days later. In the interval a noticeable change has come over the public attitude. The enthusiasm with which the country greeted the re-employment program is now much tempered, and a feeling of uncertainty concerning the execution of the program has grown up. Thus the condition confronting the President as he returns to his desk in the White House is distinctly less favorable to early effectuation of the program than it was three weeks ago.

Four principal doubts are involved in this change, in addition to the President's own action in deferring the program and disavowing the able preparatory work done at his direction. Chief of them is the fear that political influence will dominate the administration of the program, a fear not wholly imaginary, for activities of political leaders and inquiries as to party affiliations have tended to give it substance. Needless to say, political control of so tremendous an undertaking as the public-works program is bound to be fatal. Politics would have wrecked the country in the crisis of 1917, and it would wreck today's industry-control task were it allowed to enter. So also would it wreck the public-works recovery plan. It is imperative that the program be kept free of any suspicion of political domination.

Second, there is fear that the act may be throttled in application. During the three weeks' wait the President's warning of June 16 as to the danger of "too much feverish haste" has had more careful attention, and subsequent reports from Washington have added to its effect. The broad and enthusiastic cooperation of the country's citizenry in making the program effective for most rapid economic recovery is in danger of being weakened by the prospect that the program may be curbed.

Third, the possibility of bureaucratic centralization of action on the program has created apprehension. Manifestly, the army in the war against unemployment must not be hampered by swivel-chair control if victory is to be won. It is well remembered how completely the R.F.C. neutralized the Relief Act by bureaucracy of management. Should the Recovery Act be administered in like manner, hearty cooperation in making it effective cannot be expected.

Finally, there is apprehension as to whether the act will be applied for the purpose of recovery of normal business or is to become a mere device of welfare administration. Proposals to make the program an outlet for relief-roll labor strike at the very root of the act. If carried out they would cripple every construction operation under the act and utterly subvert its essential purpose of returning industry to normal; they would be even more fatal than politics.

Such fears and apprehensions give justifiable cause for feelings of uncertainty. It is to be hoped that the President will act with characteristic determination and directness to remove them—that he will rout the politicians, define the program in broad scope, provide for effectively distributed operating authority, and remove the program from all confusion with welfare functions, to the end that re-employment may be rapid and effective. For, despite inflation buying and rising prices, unemployment remains the greatest problem and the public-works program remains the key to its solution.

NEWS OF THE WEEK

Policies Formulated For Public Works Under Recovery Act

Washington Correspondence

VIGOROUS action by President Roosevelt to speed up public works is expected this week. While Secretary Ickes' board has been hard at work defining policy and procedure for carrying forward the federal-state program, conditions have been permitted to intervene that threaten to defeat its purpose in priming the pump for industrial recovery. The President will have to deal summarily with three factors to prevent the program from being dragged into a rut of sticky official and political mud.

1. There is the disposition, represented on the public works board by Lewis Douglas, Director of the Budget, to go slow in disbursing the three billion dollar construction fund in view of the increase in industrial activity and prices. This ignores the fact given wide recognition in the Industrial Recovery Administration that the improvement in business anticipates free spending by the government and may collapse if this stimulus is held back. It is by no means fair to say that a niggardly policy is favored by a majority of the board, but it is feared that a compromise of views will have the effect of curtailing the program.

2. Of greater concern is the tendency by the board, despite the liberal intent of the law, towards a strictness with regard to individual projects that is daily becoming more evident as the board is impressed by the responsibility of administering the huge fund. It was such cautious timidity that destroyed the effectiveness of the construction program directed by the Reconstruction Finance Corporation.

3. Finally, the selection of state and municipal projects now is subject to all the considerations that may dictate the action of a politician. The list of nominations for state administrators submitted to President Roosevelt was jocularly referred to by Secretary Ickes as the "telephone directory." The only qualifications of a state administrator must be those of an "outstanding citizen free from connections with any individual or firm that might embarrass him in the faithful performance of his duty."

Local approval required

Only projects that have the approval of state administrators will be considered by the public works board. The state administrator also may submit recommendations with respect to federal public works in his state, although the federal board reserves the right to pass upon federal projects independently. The federal board may, of course, turn down a state or local project that has been approved by the state administrator and his advisory committee. The board has adopted a policy of preference for public works as against private projects and, in the light of other developments, it appears that housing will not figure prominently in the construction program.

Grants up to 30 per cent of the cost of labor and materials will be made on projects that are "fundamentally necessary to the community," according to Secretary Ickes, but it is evident that the maximum permitted by the law will not invariably be paid out. "Fundamentally necessary" projects include water works and sewage disposal plants, but Secretary Ickes explained that stadiums and auditoriums might not fall into this category.

Theoretically, the states and other political subdivisions may borrow 70 per cent of the total cost of a project from the federal treasury, on top of a grant, but Secretary Ickes said they will have to make a very strong case for such a loan and they have "got to show us that they can pay us back. Their security must be good and their budget in good shape."

Interest rate set

Four per cent interest will be charged on loans for all public projects and the period of amortization has been fixed as the reasonable life of the project but not more than thirty years. Secretary Ickes had previously stated that the board was in favor of a uniform rate of interest on private and public projects but in announcing that the rate would be 4 per cent on public works he said that the rate on private projects had not been decided.

No action has been taken by the board on federal projects recommended by the government departments and agencies. The total culled from such lists by Donald H. Sawyer, public works administrator, is estimated by him at from three to four hundred million dollars, but the departments are submitting supplemental estimates for consideration. The allotments finally approved will include both reconditioning and new construction.

The board has adopted a resolution to the effect that the promoters of federal projects scattered throughout the country must bring in accurate and complete statements of total cost. So far as the board is concerned, there will be no further appropriation for a project if it is discovered that the original estimate is not, in fact, complete. Secretary Ickes explained that the board has taken this stand in order to discourage the prevalent practice in Congress of obtaining an appropriation to "complete" a project and then coming back a year or two later for more money. He stated emphatically that the board doesn't want any half finished projects left when its program is terminated; that either a complete job will be done or it will not be started.

Construction contracts

Persistent inquiries whether the board would sanction the award of contracts on a cost-plus basis have been met by the statement that this has not even been suggested. As an overlying policy, bidders on all contracts in connection with federal, state and local projects, will be expected to subscribe and adhere to codes that are established in their industries in conjunction with the industrial recovery program. Writing pre-determined wage rates into specifications is precluded from any broad application by the variety of state laws that will govern construction.

Labor policies

The federal board has allotted $500,000 to the Department of Labor to set up special reemployment agencies to select qualified workers for employers participating in the construction program. The board has announced that local labor should be selected from lists submitted by local agencies designated by the United States Employment Service. This means, according to W. Frank Persons, director of the U. S. Employment Service, that the interests of organized labor, as well as of unskilled labor, are to be recognized and that the preferences guaranteed by law are to be safeguarded.

A labor advisory board has been appointed by Frances Perkins, Secretary of Labor, consisting of Isador Lubin, chairman; Michael J. McDonough, representing the building trades department of the American Federation of Labor; William Bowen, of the bricklayers union; George Orris, of the carpenters union; and John Coefield, of the plumbers union.

Louis R. Glavis, director of the new bureau of investigation in the Interior Department, has been designated by Secretary Ickes to serve in the same capacity in the public works administration. This indicates that a secret service organization will watch every step of the program throughout the country. "We will seek," said Secretary Ickes, "to safeguard all public works undertaken by us from corruption or graft. We will see to it that works are carefully inspected during their progress so that the taxpayers of the United States who are so generously contributing to this vast fund for the common good may be assured that every dollar spent represents a dollar of value. Our concern is the employment of as much labor as possible within the limits of the appropriation of Congress. To protect the interests of labor we will do everything possible to hold contractors down to a legitimate profit."

Master Code for Contracting To Be Considered July 10

A national control committee appointed at the conference of general contractors called by the Associated General Contractors and meeting in Chicago June 25 and 26, as noted last week, is drafting a master code of practice to control contracting under the industrial recovery act. This committee, composed of both members and non-members of the Associated General Contractors, has met this week in Washington in conference with labor leaders to prepare a formal draft which will be gone over with other groups that may be interested at a meeting planned for July 10. It is expected to be able to submit the final code to the recovery administration by July 10 or 11.

Information Required for Recovery Loans in Application Form

THE INFORMATION that applicants for loans under the National Industrial Recovery Act will have to submit to the Federal Emergency Administration of Public Works is outlined in form No. 1 approved by the special public works board last week. This form is entitled "Application for Loan."

Applicants are required to present their legal authority for applying for a loan, must submit general plans of the project showing its location and general features, using as few sheets as possible to show clearly what is proposed. The plans must be accompanied by a brief statement containing the following information: Whether the work has started, whether construction plans are ready, and if not when they will be ready; the length of time required between approval of the loan and the start of work; the time required to complete the work; whether the project is part of a larger program; whether federal, state or municipal authority is required before the work can be started, and if so, what steps have been taken to secure that approval.

An estimate of cost must be given, segregated into labor, material, engineering and overhead, interest during construction, cost of land, if any, required for the project and an estimate of expenditure by months after the start of construction.

Financial information required

States, municipalities and other public bodies must give the following information concerning their financial status: (1) Present total bonded indebtedness; (2) whether there are overlapping debts on the project; (3) what is the limit of bonded indebtedness of the applicant authorized by law, both the amount in dollars and the per cent of assessed valuation; (4) what authority the applicant has to issue bonds or other securities for the work; (5) whether the applicant's budget is balanced, and if not, what steps are being taken to balance it; (6) the percentage of taxes delinquent and how long they are outstanding. A complete financial statement for the latest fiscal year must be included and a statement showing receipts and expenditures for the full year preceding.

The application also must be accompanied by a brief statement covering the following questions: (a) Necessity or convenience of the project and whether it has been approved locally; (b) character of the approval given the project; (c) general classes of labor or construction personnel that the project will benefit, and how many man-hours of labor required; (d) brief general description of the project and any additional pertinent information.

Applications are not to be submitted to the Washington office of the administrator of public works except through state administrators. State administrators are expected to be appointed early in July.

Public projects get preference

The special public works board announced after its meeting on June 28 that in the distribution of public works funds preference will be given to federal, state and municipal projects as against private projects. Housing projects are to be the subject of a further study by the board.

Under the public works section of the Recovery Act loans may be "reasonably" secured. Under the R.F.C. act they had to be "fully and adequately" secured. The definition under which loans now may be made is much more liberal and means that many projects which the R. F. C. failed to approve now may come within the law. In addition, many thoroughly meritorious projects were barred from R. F. C. loans due to the fact that all or part of their receipts came from tax monies. It is expected that in making loans to private corporations under the new act that a preferred status will be given those intended primarily for public benefit with incidental profit to the corporation. After such projects have been taken care of, consideration will be given projects that are primarily for profit but which still would serve an important public interest.

The Federal Employment Service has proposed to the special public works board that 50 per cent of the men needed on public works projects financed under the Recovery Act be taken from public relief rolls and the other 50 per cent from men who are out of work, but have not reached the point of registering on the relief roll. The board is studying this proposal.

Malcolm Muir Appointed Aide To Recovery Act Administrator

Malcolm Muir, president of the McGraw-Hill Publishing Co. has been appointed a deputy administrator under the National Industrial Recovery Act. Mr. Muir's appointment, according to the announcement of Hugh S. Johnson, administrator of the act, "represents a horizontal cross-section of industry, due to his intimate acquaintance with the problems of the 'capital goods' and machinery groups as chief executive of the McGraw-Hill magazines, and past president of the Associated Business Papers. Mr. Muir was also a member of the National Committee for Industrial Rehabilitation and chairman of its New York Board, thus having been active in industrial recovery a year before the new law was enacted."

Cove Creek Dam Construction To Start in About Six Months

While plans for the construction of Cove Creek Dam on the Clinch River will be completed by about July 20, it will be six months or more before construction begins, according to Arthur E. Morgan, chairman of the Tennessee Valley Authority. S. M. Woodward, professor of hydraulic engineering at Iowa State University, is now in the district engineer's office, U. S. Engineer Corps, at St. Louis as representative of the Tennessee board and upon completion of the plans will forward them to J. L. Savage at Denver, chief designing engineer of the U. S. Bureau of Reclamation, for review.

The first work to be undertaken, Dr. Morgan stated, is the construction of a railroad to the dam site and highway connections. He said further, "My picture of building this dam is to take twice as many people as we need and work them half time on condition that they use their spare time in educating themselves—not out of books, but how to live."

On July 1 the Tennessee Valley Authority took over the force of 280 men engaged in making surveys for the dam and for the reservoir site and the 30 men in the district engineer's office at St. Louis.

Calumet-Sag Canal Connection Not Favored by Army Engineers

Immediate construction of a channel between the Illinois waterway and the Great Lakes by way of Calumet River, Little Calumet River, Sag Channel and Lake Calumet as a first-class connection between the waterway and the lake is not favored in a report recently transmitted to Congress by the Board of Engineers for Rivers and Harbors. The board favors the adoption of that route as a future first-class connection but is unable to find transportation savings which alone would justify federal expense involved. The board recommends a moderate improvement of the Calumet-Sag Channel as a first step in the possible consummation of the more comprehensive scheme.

Engineering Examiners' Council Holds Active Meeting at Chicago

WITH twenty of the twenty-four member states represented by official delegates and four non-member states also represented, the National Council of State Boards of Engineering Examiners held one of the most active meetings in its history at Chicago, June 26-27, as one of the many organizations taking part in Engineers Week.

Complete reports were submitted by the committees on accredited engineering schools, upon uniform examinations, upon the National Bureau of Engineering Registration, and upon the Engineers' Council for Professional Development. The committee on constitution and bylaws submitted a new constitution and set of bylaws, which were adopted.

The National Council approved the charter of the Engineers' Council for Professional Development and appointed the following as its representatives: D. B. Steinman, P. H. Daggett and T. Keith Legaré.

The secretary, T. Keith Legaré, reported that fifteen states now have registration laws under consideration. During the meeting word was received of the approval of the Ohio law. The latter is based on the model law drafted by representatives of the council and the engineering societies.

The following officers were elected for the ensuing year: president, N. W. Dougherty, University of Tennessee; vice-president, Ralph J. Reed, Los Angeles; directors, G. M. Butler, Jas. L. Ferebee, D. B. Steinman and Jas. R. Rhyne. T. Keith Legaré was re-elected executive secretary.

The next meeting of the council will be held in Portland, Ore., in October, 1934.

T. R. Lawson Made President of Testing Materials Society

Thomas R. Lawson, head of the department of civil engineering at Rensselaer Polytechnic Institute, Troy, N. Y., was elected president of the American Society for Testing Materials at its annual meeting held in Chicago last week.

Prof. Lawson is a graduate of Rensselaer Polytechnic Institute in the class of 1898 and has been connected with the teaching staff of the school since that time.

Thomas R. Lawson

Previous to graduation from the Institute, he spent his summer vacations on bridge work and has continued to devote much of his time during summer vacations to bridge work and has acted as consulting engineer for bridge companies in the design or reconstruction of bridges. He also has acted as consulting engineer on hydraulic and general civil engineering work. In 1906 he was appointed professor of rational and technical mechanics, a position which he has held since that time. In 1921 Prof. Lawson was made head of the Department of civil engineering of the Institute.

Prof. Lawson has been active in the American Society for Testing Materials for many years and has served both as a member and as chairman of several of its committees.

New York State Highway Funds Allocated Under Recovery Act

A division between federal-aid system highways, secondary roads, and main highway routes through cities of the $22,330,101 allocated to New York State under the Recovery Act was approved by the special board of public works and representatives of the states on July 1. Under the proposed division of the fund, $12,294,000 will be spent on roads included in the federal-aid highway system, $5,570,000 on the extension of this system through municipalities and $4,466,000 on secondary roads. Under the plan presented to the board by Frederick Stuart Greene, superintendent of public works, and A. W. Brandt, commissioner of highways for New York State, the money will be spent in 56 of the 62 counties of the state.

Highway Engineer Resigns

Jacob L. Bauer, engineer of the state highway commission of New Jersey, resigned on June 26 when the commission began hearings into his conduct of the engineering of the highway department. As noted in our issue of June 22, Mr. Bauer was suspended by the newly-constituted highway commission and charges of incompetence were preferred against him following his refusal to resign. When Mr. Bauer resigned on June 26, he stated that he did so because he realized that regardless of how the hearings on the charges against him came out, he could not continue to work in harmony with the commission.

SOCIETY CALENDAR

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual meeting, Milwaukee, Wis., Oct. 9-11.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, annual meeting, Chicago, Oct. 17-21.

AMERICAN PUBLIC HEALTH ASSOCIATION, annual meeting, Indianapolis, Ind., Oct. 9-12.

AMERICAN SOCIETY OF MUNICIPAL ENGINEERS, annual meeting, Milwaukee, Wis., Sept. 25-27.

AMERICAN WELDING SOCIETY, fall meeting, Detroit, Mich. Oct. 2-6.

HIGHWAY RESEARCH BOARD, National Research Council, Washington, D. C., Dec. 7-8.

INTERNATIONAL ASSOCIATION OF PUBLIC WORKS OFFICIALS, annual meeting, Milwaukee, Wis., Sept. 21-23.

INTERNATIONAL CITY MANAGERS ASSOCIATION, annual conferenc, International House, Chicago, Sept. 18-20.

NATIONAL SAFETY COUNCIL, 22nd Annual Safety Congress, Chicago, Oct. 2-6.

NATIONAL ASSOCIATION OF RAILWAY AND UTILITIES COMMISSIONERS, annual meeting, Cincinnati, Ohio, Oct. 10-12.

NEW ENGLAND WATER WORKS ASSOCIATION, annual convention, Bridgeport. Conn., Sept. 19-22.

COLORADO SECTION, American Society of Civil Engineers, has elected E. L. Mosley, Colorado Springs, president, to succeed L. F. Copeland, of Denver; R. J. Tipton, vice president, and F. C. Carstarphen, secretary-treasurer.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS, at its meeting held at Purdue University, Lafayette, Ind., June 21-24, elected Arthur Huntington, Cedar Rapids, Iowa, president; M. L. Nichols, Auburn, Ala., and K. J. T. Ekblaw, Chicago, vice-presidents; Raymond Olney, St. Joseph, Mich., secretary-treasurer, and E. E. Brackett, Lincoln, Nebr., counselor.

ENGINEERING NEWS-RECORD
VOLUME 111——NUMBER 1

ENGINEERING NEWS-RECORD is a consolidation of Engineering News and Engineering Record, effected in 1917. The Contractor was consolidated with Engineering News-Record in 1918.

Engineering News was founded in 1874 by George H. Frost, as The Engineer and Surveyor, which title subsequently became The Engineer, Architect and Surveyor, then Engineering News and American Railway Journal and finally Engineering News, under the editorships of D. McN. Stauffer, A. M. Wellington and Charles Whiting Baker.

Engineering Record was established in 1877 by Henry C. Meyer as The Plumber and Sanitary Engineer. The name was subsequently changed to The Sanitary Engineer, Engineering and Building Record, and, finally, to Engineering Record. During his ownership of the paper Mr. Meyer was directly responsible for the editorial policy. John M. Goodell became editor of the paper in 1902 and was succeeded in 1913 by E. J. Mehren.

E. J. Mehren became editor of Engineering News-Record at the time of the consolidation in 1917, and was succeeded by Frank C. Wight in 1924. In July, 1928, F. E. Schmitt was appointed editor.

The editorial staff comprises: *New York:* F. E. Schmitt, editor; V. T. Boughton, managing editor; C. S. Hill, W. G. Bowman, H. W. Richardson and F. W. Herring. *Chicago:* W. W. DeBerard. *Southeast:* S. T. Henry. *San Francisco:* N. A. Bowers, J. I. Ballard.

Pier for Golden Gate Bridge Completed in Six Months Time

Started in January the north (Marin County) pier for the Golden Gate bridge has been completed. Rising 44 ft. above the water surface the structure is located at the foot of a steep cliff. Excavation was carried on behind a timber crib and rockfill cofferdam which enclosed the outer three sides of the site. Depth to satisfactory rock was only 20 ft. over most of the area but one corner was carried down to El.—34. Area of the base is 80x160 ft. with the sides tapering slightly; the base block and pier proper contain about 25,000 cu.yd. of concrete.

Completion of the Marin pier finishes the contract of the Pacific Bridge Co. on the north side of the Golden Gate and operations will be concentrated on the San Francisco pier, 1,000 ft. offshore where subaqueous blasting and dredging are well advanced.

Obituary

MAJ.-GEN. WM. BETHUNE LINDSAY, Canadian army engineer officer who organized the first Canadian engineering unit to go to France in 1914, and later commanded all the Canadian Engineer troops in France, died in Toronto, Ont., June 27, age 52 years. General Lindsay had been in ill health for some time.

MAURICE C. COUCHOT, consulting structural engineer, San Francisco, died June 29 at the age of 62 after several weeks illness. Mr. Couchot was a native of France and received his education in Paris but had spent almost 40 years in the San Francisco bay region. His professional work included the structural design of many well known California buildings including the French and Fine Arts buildings at the Panama-Pacific Exposition. He was a member of the state building code committee.

Brief News

PROGRESS NOW BEING MADE on the new bridge spanning the St. Lawrence river between Ville LaSalle and Caughnawaga indicates that the structure will be opened to traffic one year ahead of the scheduled time. The project is costing about $3,000,000.

SUIT OF THE AMERICAN AIRWAYS, INC., to prevent the Louisiana authorities from forcing payment of the 5c. state tax on gasoline when used as motor fuel by the aviation company was lost in an adverse decision handed down by special three judge court tribunal. A similar case brought by the Trinity Farms Construction Co. recently was decided against the contractor.

TURNER CONSTRUCTION CO., of New York, Philadelphia and Boston, and the Rostock & Baerlocher Co., of Vienna, Berlin and Paris, have formed the Turner-Rostock Corp. for the purposes of constructing in the United States and Canada reinforced concrete fermenters in storage tanks lined by a special Rostock process for storing such liquids as beer, wine and alcohol.

Highway Engineer Examination Held by U. S. Civil Service

The United States Civil Service Commission will receive up to July 14 applications for the position of senior highway construction supervisor and senior highway design engineer at salaries ranging from $4,600 to $5,400 a year, less the statutory deduction of 15 per cent and a retirement deduction of 3½ per cent. Competitors will not be required to report for a written examination, but will be rated on education and experience. Information may be obtained from the Washington office of the commission, or from the civil service office at city post offices or customhouses.

Reservoir Survey in Quebec

Engineers of the Quebec Stream Commission are engaged upon a survey to determine the area required for a storage reservoir at the headwaters of the Rimouski River, about midway between the Quebec-New Brunswick boundary and the St. Lawrence River. The Rimouski is one of the principal tributaries running into the St. Lawrence River from the Gaspe Peninsula and is a possible source for hydro-electric power in that region.

Georgia's Federal Road Funds Held Up Pending Inquiry

Notice that further payment of federal road funds to Georgia will be withheld until it has been determined that the state has a satisfactory highway department has been given by Acting Secretary of Agriculture R. G. Tugwell to J. W. Barnett, chairman of the state highway board, whose removal has been ordered by Governor Eugene Talmadge. Following action by the governor in placing the highway department under martial law and ordering the removal of two board members and others, including the chief engineer, Mr. Tugwell called attention to the requirement of the federal highway legislation that the state must maintain a highway department having adequate powers to carry on the cooperative roadwork and the fact that the determination that such conditions exist rests with the Secretary of Agriculture. He also gave notice that more than $10,000,000 that is to be apportioned to the state under the national industrial recovery act will not be available unless the Secretary shall find that the state has a highway department capable of discharging satisfactorily the duties required.

Moses E. Cox was named chief engineer of the state highway department on June 20 by Commissioner J. D. Wilhart, acting as the entire highway board under Governor Talmadge's martial law proclamation. Mr. Cox was previously dismissed from the department by D. E. McWhorter, former chief engineer, whom he succeeded in office.

World's Deepest Bridge Piers Approved by U. S. Road Bureau

The U. S. Bureau of Public Roads has formally approved the four major piers for the highway bridge across the Atchafalaya River at Morgan City, La. The piers are the deepest yet constructed, extending 176.5 ft. below low water as against 162.5 ft. for the piers of a bridge at Hawkbury, Australia.

Title to the honor of having the deepest piers will not remain with the Morgan City bridge for any length of time, however, as the piers for the new Mississippi River Bridge at New Orleans are expected to reach a depth of 185 ft. and still greater depths will be reached in the bridge work at San Francisco.

Steel work for the Morgan City bridge is being fabricated at the plant of the Mount Vernon Bridge Co., Mount Vernon, Ohio, and is to be assembled on falsework near the site and floated into position. It is expected to have the bridge completed by the first of January.

Contracts and Capital

CONSTRUCTION

(Thousands of Dollars)

	Weekly July 1932	Average Four Weeks	Week July 6, 1933
Federal Government	$11,176	$385	$20
State and municipal	11,949	8,714	3,389
Total public	$23,125	$9,099	$3,409
Total private	6,989	9,206	5,102
Week's total	$30,114	$18,305	$8,511
Cumulative to date:			
1932		$628,229	
1933		454,141	

NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

	Weekly July 1932	Average Four Weeks	Week June 30, 1933
New capital issues	$19,000	$15,442	$37,299
Cumulative to date:			
1932		$420,000	
1933		169,756	

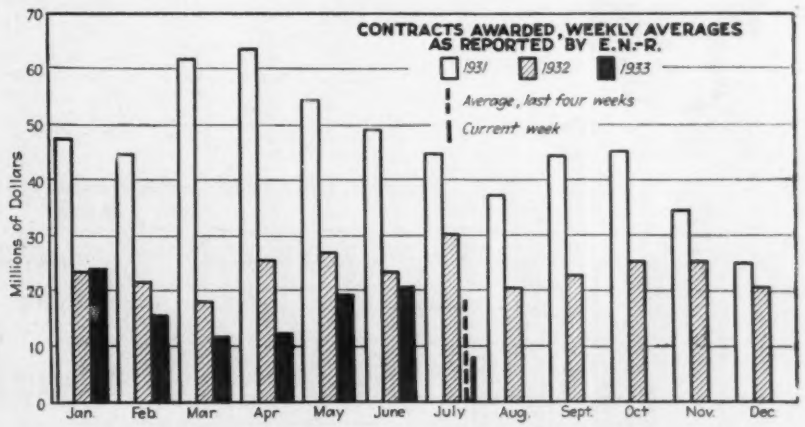
ENR Cost and Volume Index

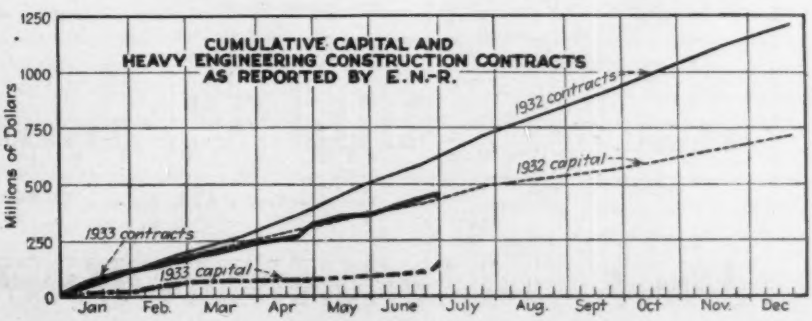
E.N.-R. Cost		E.N.-R Volume	
July, 1933	165.50	June, 1933	100
June, 1933	163.41	May, 1933	103
July, 1932	153.36	June, 1932	131
1932 (Average)	136.97	1932 (Average)	127
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.35	1930 (Average)	260
1913 Average	100		

Engineering Contracts and Capital

HEAVY engineering construction contracts reported last week total only $8,511,000, following two high weeks of $23,000,000 and $29,000,000. The low volume reported is for the most part accounted for by the closing of these pages one day early on account of the holidays, which eliminated the heaviest day of the week from the construction reports. Public awards reported total $3,409,000, while private contracts again exceeded public lettings with $5,102,000. Federal awards were the smallest ever reported, amounting to only one contract valued at $20,000.

New productive capital issues reported for the week are the heaviest of the year, totaling $37,299,000. The state of New York sold $26,595,000 in bonds at the lowest interest in the financial history of the state, 2.936 per cent. The R.F.C. purchased $8,064,000 in bonds of the Metropolitan Water District of Southern California on previous commitments for financing the Colorado River aqueduct.





Business Side of Construction

Construction Gains in June; Private Contracts Above Public

FOR THE FIRST TIME since October, 1931, private engineering construction in June was greater than the public works volume. All contracts reported in June (five weeks) total $104,200,000, or 20.9 millions per week. Private work averaged 10.9 millions per week, while the weekly average of public works was 10 millions. Private contracts have not been so high since late in 1931. Industrial building contracts reported during the month, aggregating nearly $35,000,000, accounts for the increase in private work. Nearly $12,000,000 in unclassified awards, mostly for gas pipelines, also swelled the private total. The bulk of public works volume came from two classifications, highway lettings totaling $20,000,000 and waterworks (mostly Colorado River aqueduct tunnels) amounting to $12,500,000. Public buildings, usually a large item in public works, felt the effect of the federal ban on new buildings pending the start of the administration's construction program, and amounted to only $7,500,000.

In the geographical distribution of contracts in June, gains were registered by four of the six districts. The Middle Atlantic section showed the greatest increase, contracts in June averaging 6.3 millions per week as compared with 2.4 millions in May. In the West of the Mississippi area, contracts in June were 4.8 millions against 1.2 millions per week the previous month. The South and Middle West districts also showed gains. New England remained practically the same as for May, while the Far West registered a heavy loss, due to the high May volume including the San Francisco-Golden Gate bridge contracts.

During the first six months of 1933, contracts totaled $445,600,000, about 75 per cent of the volume reported the first half of 1932.

Materials notes

Steel—Steel operations have continued to expand steadily since touching a low point of ingot production of 14 per cent of capacity late in March. During the closing week of June, ingot production reached 53 per cent of capacity for the country as a whole, the highest output in two years. The average output in May was 34.11 per cent, with the month closing at 43 per cent. Additional blast furnaces have been fired in many steel centers, materially adding to the employment roll.

The American Iron & Steel Institute reports that in May ingot production amounted to 2,001,991 tons, bringing the total output for the first five months of the year up to 6,391,675 tons. The average output for the first five months is rated at 22.79 per cent of capacity.

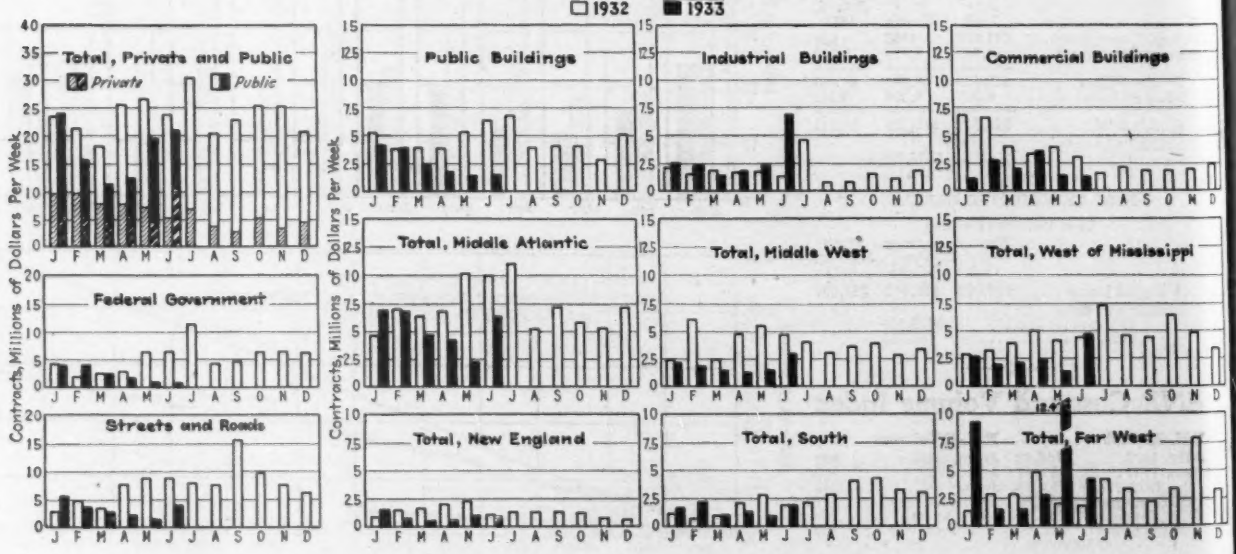
While steel production has been increasing for three months, the American Institute of Steel Construction reports that during May steel construction bookings

ENGINEERING CONSTRUCTION CONTRACTS REPORTED IN JUNE, 1933

Five Weeks—Thousands of Dollars (000 omitted)

	New England	Middle Atlantic	South	Middle West	West of Mississippi	Far West	United States June 1933	United States Six Months 1933	United States Six Months 1932	Canada June, 1933
Public Works										
Waterworks	95	324	198	952	373	10,494	12,436	52,249	12,598	102
Sewers	176	293	97	510	95	76	1,247	8,335	13,913	.....
Bridges, public	67	2,265	.....	474	168	101	3,075	51,075	26,000	505
Earthwork and waterways	162	224	1,039	15	448	657	2,545	22,956	28,669	98
Streets and roads	970	3,738	3,893	6,784	3,533	1,015	19,933	83,824	157,930	126
Buildings, public	418	3,283	17	314	3,061	345	7,438	62,319	123,294	188
Unclassified, public	85	131	.....	179	138	2,531	3,064	6,874	29,100	30
Total public	1,973	10,258	5,244	9,228	7,816	15,219	49,738	287,632	391,504	1,049
Federal gov't. (included in above classifications)	29	293	1,065	255	443	723	2,808	54,941	105,504	.....
Private										
Bridges, private	.....	.....	.....	224	73	.....	297	3,439	2,084	.....
Buildings, industrial	1,135	12,769	1,166	3,711	15,244	543	34,548	77,372	45,318	280
Buildings, commercial	1,205	4,084	169	223	343	105	6,129	48,619	117,129	401
Unclassified, private	183	4,401	1,251	1,508	547	5,598	13,488	28,568	42,080	25
Total, private	2,523	21,254	2,586	5,666	16,189	6,246	54,462	157,998	206,611	706
June, 1933 (5 weeks)	**9,084**	**31,512**	**7,830**	**14,894**	**24,003**	**21,465**	**104,200**	.....	.....	**1,755**
May, 1933 (4 weeks)	4,010	9,523	4,120	6,434	4,658	49,453	78,198	.....	.....	1,594
June, 1932 (5 weeks)	5,250	49,857	9,139	23,339	22,279	8,723	118,587	.....	.....	1,058
Six months, 1933	22,083	134,985	39,219	50,854	67,368	131,121	.....	445,630	.....	3,349
Six months, 1932	42,966	221,493	41,536	114,408	105,335	72,377	.....	.....	598,115	21,248

CONTRACTS REPORTED - WEEKLY AVERAGES - 1932-1933



were at a long-time low, amounting to 35,468 tons, though shipments increased over the previous month, totaling 62,642 tons.

Cement—Several large orders for cement were reported in June. Illinois bought 2,000,000 bbl. for highway work; Mississippi ordered an additional 1,000,000 bbl.; and 400,000 bbl. were purchased for Boulder Dam. In May, according to the U. S. Bureau of Mines, the cement industry produced 6,266,000 bbl., shipped 6,748,000 bbl. and had in stock at the end of the month 20,060,000 bbl. Production showed a decrease of 9.4 per cent and shipments a decrease of 15.9 per cent, as compared with May, 1932. Stocks on hand were 21 per cent lower than a year ago. Production in May was rated at 27.4 per cent of capacity, as compared with 18.9 per cent in April and 30.2 per cent in May, 1932.

Lumber—Sales of lumber continued to increase during June. Shipments consistently surpass production in the endeavor to reduce stocks on hand at the mills. With the increase in lumber business, prices are climbing. Many distributing centers report increases in prices, some ranging as high at $5 per thousand feet.

Labor notes

Estimates of the American Federation of Labor place the increase in employment during April and May at 1,629,000, with indications pointing to a continuation of the rise in jobs through June. May showed a gain of 1,000,000 in employment. The peak of unemployment was reached in March with 13,359,000 unemployed.

St. Louis—An ordinance has been passed requiring that the prevailing wage scale must be paid on all municipal construction work, both day labor and contract.

Pittsburgh—Union agreements expired June 1. Only one trade, painters, has signed a new agreement. Other trades are marking time pending new arrangements under the National Recovery Act. Millwrights working on the new postoffice have been installing the conveyors, which the ironworkers claim. A strike arising from this dispute is holding up work.

Cincinnati—Slight improvement in construction labor circles has been noted. A census of workers of all classes shows that 51.67 per cent are employed full time; 22.23 per cent are part-time workers; and 26.1 per cent are out of work. This last figure is the same as a year ago.

Washington, D. C.—Efforts are being made by employers to cut the rate of plasterers from $14 per day to $10. The higher rate was interpreted by the labor department as being the "prevailing wage" and has been forced on all government building work. Employers declare the rate is unreasonable and that much small work is being delayed because of it.

San Francisco—There are 12 per cent more men at work in the building trades in San Francisco than there were last year at this time, according to a survey made by the Industrial Association. The census, taken June 20, shows 2,567 building trades mechanics employed.

Jacksonville—An ordinance has been passed providing that the city shall specify rates of wages to be paid on all city contract work.

Massachusetts—The number of men employed on highway work in the state during May showed an increase over the April employment total.

Massachusetts—During May an average of 2,247 workers were on highway construction, as compared with 1,914 in April. The average man hours per week increased from 71,997 to 91,065. The average rate of pay in May was 53.9c.

CURRENT BUILDING AND CONSTRUCTION TRADES WAGE RATES PER HOUR

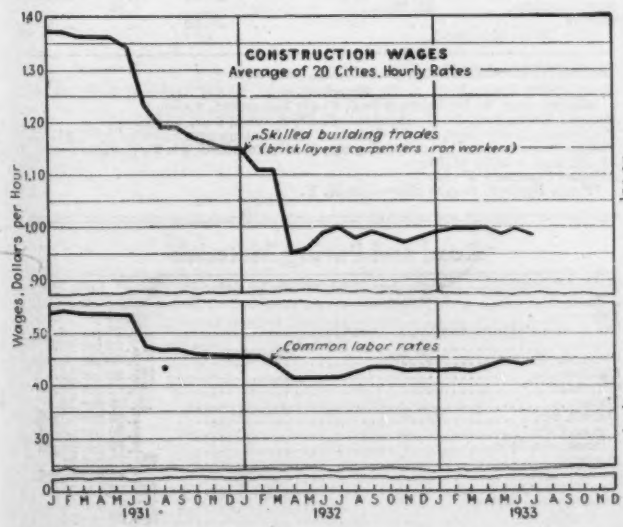
Cities	Bricklayers	Carpenters	Hoisting Engineers	Pile Drivers	Structural Iron Workers	Masons' Laborers	Common Laborers
Atlanta	$0.75@1.12½	$0.40@.90	$0.60@1.25	.....	$0.60@1.25	$0.25	$0.20@.25
Baltimore	1.00	.90	1.00@1.37½	$0.65	1.00@1.25	.40	.30
Birmingham	.75@.87½	.60	.75	.....	.75	.25	.20@.30
Boston	.90@1.30	.60@1.17½	.90@1.17½	.70@1.07½	1.00@1.20	.45@.70	.45@.70
Cincinnati	1.27½	1.02½	1.07½	1.07½	1.20	.70	.40@.45
Chicago	1.37½	1.31½	1.31½	1.31½	1.35	.88½	.82½
Cleveland	.90@1.37½	.75@1.12½	.90@1.12½	1.00	.90@1.06½	.56½	.30@.72
Dallas	.62½	.50	.50	.50	.50	.25	.25@.35
Denver	1.00@1.12½	.75@.87½	.75@.87½	.....	.75@.87½	.50	.31½@.50
Detroit	1.00	.70@.75	.75	.75	.80	.40	.35@.40
Kansas City	1.30	1.00	1.06	1.06	1.00	.70	.35@.60
Los Angeles	.62½	.50	.75	.75	.75	.50@.62½	.40@.50
Minneapolis	.90@1.00	.75	.75	.....	.90	.50	.40@.50
New Orleans	1.00	.75	1.00	.70	1.25	.25@.40	.15@.25
New York	1.50@1.65	1.25@1.40	1.50@1.65	1.50	1.65	.81½@1.00	.50@.75
Philadelphia	.75@1.00	.50@.75	.75@1.00	.60@.75	.75@1.00	.20@.35	.20@.30
Pittsburgh	.60@1.50	.60@1.25	.60@1.37½	1.00@1.18½	.60@1.37½	.50	.40@.70
St. Louis	1.50	1.25	1.35@1.47	1.25	1.47	1.00	.35@.78½
San Francisco	1.12½	.90	1.00	1.00	1.20	.75	.65
Seattle	.75@1.20	.50@.90	1.00	.90	1.10	.66	.40@.50
Montreal	.75	.60	.55	.....	.70	.40	.20@.30

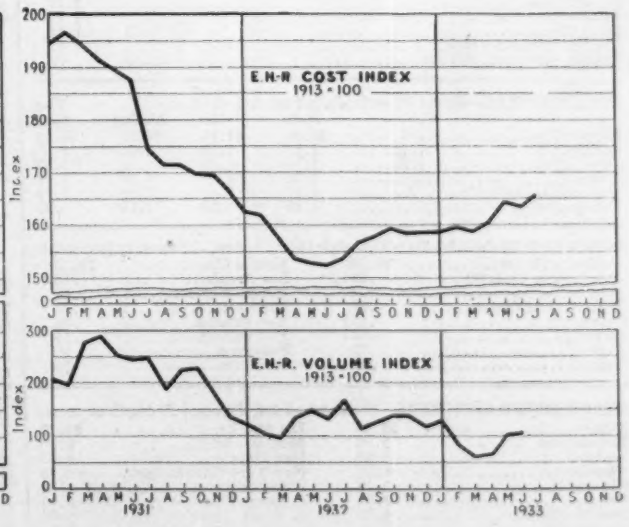
Skilled Average (3 trades) $0.985 Common Average, $0.443

ENR Cost and Volume Index

The *Engineering News-Record* Construction Cost Index for July, at 165.5, stands at the highest point reached since December, 1931. In June the Index was 163.41. The increase is due to a combination of a rise in the average common labor rates and an increase in lumber prices. No change was noted in the cement and steel components of the Index. The average of common labor rates reported from 20 cities is 44.3c., as compared with 43.9c. in May. The *ENR* Construction Volume Index for June is 109, the highest since January of this year.

E.N.-R. Cost		E.N.-R Volume	
July, 1933	**165.50**	**June, 1933**	**109**
June, 1933	163.41	May, 1933	103
July, 1932	153.36	June, 1932	131
1932 (Average)	156.97	1932 (Average)	127
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.35	1930 (Average)	260
		1913 Average	100





Current Prices of Construction Materials

Building Materials

PORTLAND CEMENT — Prices are for carload lots. For cement in returnable cloth bags add 40c. per bbl.; in non-returnable paper bags add 15c. per bbl., to following net prices:

	F.o.b.	Delivered		F.o.b.	Delivered
Atlanta	$2.38	$2.95	Kansas City	$1.75	$1.85
Baltimore	....	2.03	Los Angeles	2.10	....
Birmingham	2.02	2.12	Minneapolis	2.20	2.35
Boston	1.92	2.12	Montreal	1.70	....
Chicago	1.60	1.95	New Orleans	1.90	2.20
Cincinnati	2.31	2.46	New York	1.88	2.20
Cleveland	1.77	2.00	Philadelphia	1.94	2.04
Dallas	2.30	2.45	Pittsburgh	1.87	2.32
Denver	2.65	2.81	St. Louis	1.74	2.15
Detroit	1.90	2.05	San Francisco	2.05	....
			Seattle	2.55	2.70

Current mill-prices per barrel to dealers, for carloads of 132 barrels or over, without including charge for four bags, f.o.b. Bag charges same as in preceding table:

Alpena, Mich	$1.40	Mason City, Ia	$1.45
Buffington, Ind	1.35	Norfolk, Va	1.61
Dallas, Tex. (Inc. 5c. tax)	1.80	Northampton, Pa	1.40
Hannibal, Mo	1.35	North Birmingham, Ala	1.60
Hudson, N. Y	1.50	Richard City, Tenn	1.70
Independance, Kan	1.45	Saginaw, Mich	1.25
Ironton, Ohio	1.35	Steelton, Minn	1.55
Iola, Kan	1.45	Universal, Pa	1.40
La Salle, Ill	1.35	Waco, Tex	1.75
Limedale, Ind	1.35	Wyandotte, Mich	1.30

SAND AND GRAVEL — Per ton, carload lots, gravel, size ¾-in.:

	Gravel		Sand	
	F.o.b.	Delivered	F.o.b.	Delivered
Atlanta	$2.11	$2.61	$1.50	$1.90
Baltimore	....	2.35	....	2.08
Birmingham, per cu.yd	....	3.00	....	2.40
Boston	1.40	1.65	.90	1.15
Chicago, per cu.yd	....	2.25	....	2.25
Cincinnati	1.20	1.65	.95	1.40
Cleveland	....	2.00	1.40	2.00
Dallas, per cu.yd	1.40	2.40	1.65	2.40
Denver, per cu.yd	1.75	....	1.15	....
Detroit	.75	1.75	.75	1.45
Kansas City (at plant)	.65	....	.60	....
Los Angeles	1.45	1.60	1.00	1.10
Minneapolis	....	1.60	....	.75
New Orleans	1.40	2.40*	1.20	2.00*
New York, per cu.yd	1.50	3.50	1.00	2.25
Philadelphia	....	1.85	....	1.52
Pittsburgh	....	1.20	....	1.40
St. Louis	.80	1.40	.80	1.25
San Francisco	1.65	....	1.65	....
Seattle, per cu.yd	1.75	....	1.75	....

*Cu.yd.

CRUSHED STONE — Per ton, size 1½-in., carload lots, limestone:

	F.o.b.	Delivered
Atlanta	$1.50	$2.00
Baltimore	....	2.60
Birmingham	.80	1.05
Boston	1.40	1.65
Chicago, per cu.yd, 2,500 lb	....	2.25
Cincinnati	1.65	1.85
Cleveland	....	2.00
Dallas, per cu.yd., 2,500 lb	1.65	3.00
Denver, granite, per cu.yd., 2,700 lb	....	2.50
Detroit	....	2.00
Kansas City (at plant)	1.00	....
Los Angeles	1.45	1.60
Minneapolis	....	1.60
New York, per cu.yd., 2,800@3,000 lb	1.65	3.25
Philadelphia	....	2.20
Pittsburgh	....	2.25
St. Louis	1.05	1.65
San Francisco, trap rock	....	1.65
Seattle, per cu.yd., 3,000 lb	1.10	....

CRUSHED SLAG—Prices for carloads, per net ton, at plant:

	1½-In.	¾-In.	Roofing	Slag Sand
Birmingham	$0.90	$1.15	$2.05	$0.55
Buffalo	1.35	1.35	1.85	1.25
Cleveland	1.70	1.70	....	1.35
Toledo	1.20	1.20	1.20	1.10
Western Pennsylvania	1.25	1.25	2.00	1.25
Youngstown	1.10	1.20	2.00	.75

CONCRETE BLOCKS—Standard, 8x8x16-in., hollow, delivered to job, each:

Baltimore (8x12x12)	$0.20	Kansas City	$0.18
Birmingham (5x8x12)	.084	Los Angeles	.125
Boston	.14	Minneapolis	.10
Brooklyn and Queens	.09	Montreal	.12
Chicago	.175	New Orleans	.16
Cleveland	.165	Philadelphia	.15
Denver	.15	Pittsburgh	.18
Detroit	.07	St. Louis	.14

READY MIXED CONCRETE—Per cu.yd., 1:2:4, delivered 50 cu.yd. or more:

Atlanta	$8.00	Los Angeles	$6.10
Birmingham	5.00	Minneapolis	6.00
Boston	6.00	New Orleans	6.05
Cleveland	6.20	New York (Manhattan)	8.50
Cincinnati	6.10	Philadelphia	6.84
Dallas	7.00	Pittsburgh	6.05
Detroit 1:2½:5	4.75	St. Louis	6.80
Kansas City	7.50	Seattle	5.35

HOLLOW TILE—Building tile per block, delivered to contractors in lots of 2,000 pieces or over:

	4x12x12	6x12x12	8x12x12	10x12x12	12x12x12
Atlanta	$0.09	$0.11	$0.13	$0.20	$0.25
Baltimore	.10	.14	.20	.22	.30
Birmingham	.089	.122	.167	.219	.25
Boston	.0775	.1065	.1453	.1799	.208
Chicago	.0484	.063	.09	.1179	.13
Cincinnati	.06815	....	....	.165	....
Cleveland	.048	.066	.09	.117	.13
Dallas	.0455	....	....	.117	....
Denver	.085	.135	.175	.19	.25
Detroit	.0505	.065	.0947	.1175	.1305
Kansas City	.0735	.092	.15	.1777	.20725
Los Angeles	.085	....	....	.22	....
Minneapolis	.0692	.0988	.1372	.1447	.2029
New Orleans	.08	....	....	.22	....
New York	.076	.118	.147	....	....
Perth Amboy	....	....	....	.2388*	.2956*
Philadelphia	.065	.093	.14	.175	.195
Pittsburgh	.0435	.065	.088	.1165	.126
St. Louis	.06	.082	.112	.155	.19
San Francisco	.0765	.105	.1765	....	....
Seattle	.085	.115	.18	....	....

*At plant. (Load-bearing tile).

BRICK — Prices per thousand in carload lots, as follows:

	Common		Paving
	F.o.b.	Delivered	Backing F.o.b. 3x8½x4-in.
Atlanta	$9.00	$12.50	$32.00
Baltimore	....	12.00	43.00†
Birmingham	10.00	12.50	25.00
Boston	11.50	13.00	30.00
Chicago	....	9.00	32.00
Cincinnati	13.50	16.00	36.50
Cleveland	12.00	14.00	33.00
Dallas	8.50	10.00	25.00†
Denver	13.00	....	40.00
Detroit	....	11.50	35.25
Kansas City	12.00	14.00	35.00
Los Angeles	....	11.00	....
Minneapolis	....	6.50	....
Montreal	21.25	....	....
New Orleans	11.00	14.00	40.00
New York	9.50	12.50	45.00
Philadelphia	....	13.00	40.00
Pittsburgh	11.00	13.00	35.00
St. Louis	....	11.00	36.00†
San Francisco	....	14.00	45.00*
Seattle	12.00	14.00	....

*2½x8½x4 in. †3½x8½x4 in.

LIME — Prices of hydrated, per ton, in paper; lump, per 180-lb. bbl., net:

	Hydrated				Common Lump,	
	Finishing		Common			
	F.o.b.	Delivered	F.o.b.	Delivered	F.o.b.	Delivered
Atlanta	$17.50	$20.00	$11.50	$14.00	....	$2.50
Baltimore	....	23.50	....	13.00	....	....
Birmingham	21.00	....	12.00	....	$1.65	....
Boston	16.00	18.50	11.50	15.00	2.65*	3.50*
Chicago	....	20.00	....	14.00	....	2.75
Cincinnati	13.50	14.50	8.65	9.65	....	....
Cleveland	13.00	18.00	11.50	16.00	....	2.50
Dallas	....	20.00	....	....	....	2.75
Denver	....	30.00	....	22.00	....	2.85*
Detroit	12.75	17.50	7.25	12.00	....	....
Kansas City	19.00	20.00	....	20.00	....	2.75
Los Angeles	....	22.00	....	19.00	....	2.00
Minneapolis	....	21.00	....	19.00	....	1.70
Montreal	....	....	12.00	13.00	....	....
New Orleans	17.00	24.50	10.00	13.00	1.66	1.95
New York	14.20	18.00	11.10	15.00	2.65*	3.55*
Philadelphia	14.55	19.00	10.90	14.45	....	1.28
Pittsburgh	14.50	16.00	9.95	11.45	1.85	2.35
St. Louis	....	22.00	....	20.00	....	2.75
San Francisco	22.50	....	19.00	....	1.59	....
Seattle	....	32.00	....	24.00	....	2.80

*Per 280-lb. bbl. (net.)

LIMESTONE—Mill blocks, f.o.b. siding, per cu.ft.:

New York:* Rustic buff, $1.38; Standard gray, $1.48; Standard buff, $1.58; Selected gray, $1.58; Selected buff, $1.68; Variegated, $1.38.
Boston: Rustic buff, $1.47; Standard, $1.57; Selected buff, $1.67.
Pittsburgh: Rustic buff, $1.14; Standard, $1.24 at quarry; Selected buff, $1.34.
Philadelphia: Sel. buff, $1.59; Sel. gray, $1.49; Standard, $1.49; Standard gray, $1.39; Rustic buff, $1.39.
Atlanta: Standard $1.26.
*F.o.b. Bedford, freight allowed to N. Y.

Road and Paving Materials

PAVING STONE — Granite, lots of 50,000 blocks, 4x8x4-in., dressed, f.o.b. city:

Atlanta	$3.00 per sq.yd.
Baltimore	43.00 per M.
Birmingham (3½x8½x4-in.)	76.25 per M.
Boston	75.00 per M.
Chicago, 5 in	3.80 per sq.yd.
Cincinnati	110.00 per M.
Cleveland	96.00 per M.
Dallas	25.00 per M.
Detroit, 5 in	2.80 per sq.yd.
Kansas City	2.75 per sq.yd
Minneapolis, 4½ in	2.80 per sq.yd
Montreal	104.75 per M.
New Orleans	2.80 per sq.yd.
New York, 5 in	135.00 per M.
Philadelphia, 4x10x5	115.00 per M.
Pittsburgh	115.00 per M.
St. Louis, 5 in	2.80 per sq.yd.

Current Prices of Construction Materials

Road and Paving Materials—Continued

WOOD-BLOCK PAVING — Prices f.o.b., in carload lots:

	Size of Block	Treatment	Per Sq.Yd.
Atlanta	3½	16	$2.25
Boston	3½	16	2.00
Chicago	3½	12	1.90
Kansas City	3½	16	2.75
Minneapolis	2½	8	1.65
Montreal	3½	16	2.63
Philadelphia	3½	16	2.02
St. Louis	3½	16	2.00

CURBING—Per lin.ft., 5x16 in., straight, rough, f.o.b., in carload lots:

Atlanta	$0.41	Kansas City	$0.60
Birmingham	.50	New York	.58
Boston	.60	Philadelphia (6x20 dressed)	1.40
Dallas	.60	Pittsburgh	.80
Detroit	.45	St. Louis	.70

ASPHALT—Paving asphalt, f.o.b., per ton. Packages are 350-lb. bbl. or 425-lb. drums, in carload lots:

	Packages	Tank-car or -boat
Atlanta	$21.60	$17.40
Baltimore	19.00	15.00
Birmingham	.....	11.00
Boston	20.00	16.00
Chicago	22.50	15.50
Cincinnati (f.o.b. refinery)	16.00	14.00
Cleveland	18.00	14.00
Dallas	.....	27.00
Denver	27.50	.....
Detroit	18.29	14.29
Kansas City (f.o.b. refinery)	18.00	12.00
Los Angeles	16.50	10.50
Maurer, N. J. (Bermudez)	.....	26.00
Maurer, N. J. (Trinidad)	.....	22.00
Minneapolis (f.o.b. Twin Cities)	23.30	18.30
Montreal (f.o.b. factory)	18.66	13.00
New Orleans	17.00	13.00
New York	19.00	15.00
Philadelphia	17.00	11.00
Pittsburgh	25.00	16.00
St. Louis	21.70	17.70
San Francisco (f.o.b. refinery)	16.00	10.00
Seattle	21.10	16.00

LIQUID ASPHALT — Residual, hot application, f.o.b., in tank cars, 8,000 gal. minimum, per gal.:

Atlanta	$0.0689
Baltimore	.06
Birmingham	.06
Boston	.06
Cincinnati	.075
Dallas	.05
Kansas City	.05
Los Angeles	.05
Montreal at (refinery)	.09
New York	.06
Philadelphia	.08
Pittsburgh	.05
St. Louis	.07

EMULSIFIED ASPHALT — For penetration and surface treatment, per gal.:

Boston, applied	$0.13
Cincinnati, f.o.b. refinery	.06
Los Angeles, applied	.13
Des Moines, applied	.14
New York, applied	.15
Philadelphia, applied	.15
St. Louis, applied	.13
Seattle, f.o.b. refinery	.08

Iron and Steel

	Pittsburgh	Chicago	Birmingham
STRUCTURAL SHAPES AND PLATES, per 100 lb., base, carload lots	$1.60	$1.75	$1.75
CONCRETE REINFORCING BARS, ½ in., billet, per 100 lb., carload lots	1.65	1.65	1.75
SHEETS, per 100 lb., carload lots:			
Hot-rolled No. 10	1.60	1.90	1.65
Hot-rolled annealed No. 24	2.20	2.35	2.25
Galvanized No. 24	2.80	2.95	2.85
RIVETS per 100 lb., ½ in., structural, carload lots	2.50	2.35	2.30
SHEETPILING, per 100 lb., base, carload lots	1.90	2.05	.....
WIRE NAILS, per 100 lb., base, carload lots	1.85	2.05	2.30
HEAVY MELTING STEEL SCRAP, No. 1, per gross ton, at consuming point	11.50@12.00	9.25	8@8.50

TRIANGLE MESH—Plain, per 100 sq.ft., in carload lots:

Style Number	Size, In.	Weight in Pounds Per 100 Sq.Ft.	Pittsburgh Mill	Chicago District Mill
032	4x4	22	$0.94	$0.96
049	4x4	28	1.19	1.22
068	4x4	35	1.45	1.49
093	4x4	45	1.87	1.91
126	4x4	57	2.31	2.37
153	4x4	68	2.75	2.82
180	4x4	78	3.16	3.24
245	4x4	103	4.17	4.27
287	4x4	119	4.82	4.94
336	4x4	138	5.59	5.73
395	4x4	160	6.48	6.64
036P	4x8	17	.71	.73
033P	4x8	24	1.01	1.03

TRIANGLE MESH—*Continued*

Style Number	Size, In.	Weight in Pounds Per 100 Sq.Ft.	Pittsburgh Mill	Chicago District Mi
072P	4x8	31	1.27	1.30
097P	4x8	40	1.64	1.68
049R	4x8	24	1.01	1.03
067R	4x8	31	1.27	1.30
089R	4x8	40	1.64	1.68

WIRE ROPE—Discounts from manufacturers' list prices on regular grades of bright and galvanized, Eastern Territory, New York, and East of Missouri River:

	Base
Cast steel round strand rope	20 %
Galvanized iron rigging and guy rope (add to list)	12½%
Galvanized steel rigging and guy rope	7½%
Plow steel round strand rope	35 %
"Special Steel" and extra strong cast steel, round strand rope	27½%

Discount 5 points less than discount for Eastern territory: California, Colorado, Kansas, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Washington and Wyoming. Discount 10 points less than discount for Eastern territory: Arizona, Idaho, Montana and Utah.

EXPANDED METAL LATH—Per 100 sq.yd., painted, f.o.b., in carload lots 2.2 lb. per sq.yd., standard-mesh diamond lath:

Atlanta	$15.00	Los Angeles	$17.00
Birmingham	17.00	Montreal (2.5 lb.)	24.00
Boston	15.00	New Orleans	20.00
Chicago	10.60	New York	13.50
Cincinnati	11.00	Philadelphia	13.50
Dallas	16.00	Pittsburgh	13.50
Detroit	18.00*	St. Louis	19.00*
Kansas City	17.00*	San Francisco	17.00*
*Delivered.		Seattle	17.00

STEEL FREIGHT RATES — Per 100 lb., effective Dec. 3, 1931, on finished steel products in the Pittsburgh District, including plates, structural shapes, merchant-steel bars, pipe fittings, plain and galvanized wire nails, rivets, spikes bolts, flat sheets (except planished), chains, etc.; 40,000 lb. per car:

Atlanta, 36,000 lb.	$0.60	Detroit	$0.285
Baltimore	.29	Kansas City	.59
Birmingham	.60	New Orleans, 36,000 lb.	.69
Boston	.42	New York, 40,000 lb.	.35
Buffalo	.255	Pacific Coast, 60,000 lb.	1.17*
Chicago	.36	Philadelphia	.31
Cincinnati	.285	St. Louis	.41
Cleveland	.205	St. Paul	.60
Denver	.92	* All rail.	

Railway Materials and Supplies

STEEL RAILS — Per gross ton, f.o.b.

	Pittsburgh	Birmingham	Chicago
Standard rails	$40.00	$40.00	$40.00
Light rails	30.00	30.00	30.00
Re-rolled rails	26.00	.....	27.00

RAILWAY TIES — Prices f.o.b., per tie, for carload lots:

		6 In. x 8 In. by 8 Ft.	7 In. x 9 In by 8½ Ft.
Boston	Oak, untreated	$0.90	.....
	Pine, untreated	.85	.....
	Pine, creosoted	1.40	.....
New York	Long-leaf sap pine, untreated	.80	$1.00
	Mixed oak, untreated	....	1.00
Birmingham	White oak, untreated	.75	.95
	White oak, creosoted	1.35	1.45
	Southern pine, untreated	.35	.80
	Southern pine, creosoted	.95	1.35
Chicago	White oak, untreated	1.05	1.35
	Oak, empty cell, creosoted	1.40	1.80
	Oak, zinc treated	1.25	1.65
	Southern pine, creosoted	1.15	1.50
Los Angeles	Fir, untreated	.45	....
	Fir, creosoted	1.15	....
Philadelphia	Red oak, untreated	.95	1.15
	Red oak, creosoted	1.47	1.90
St. Louis	White oak, untreated	.95	1.40
	Red oak, untreated	.85	1.30
	Red oak, creosoted	1.22	1.80
	Sap pine or cypress, untreated	.75	1.10
San Francisco	Douglas fir, green, untreated	.45	.63
	Douglas fir, empty cell, creosoted	1.14	1.56
Montreal	Birch or maple, untreated	1.00	1.00
	Birch or maple, creosoted	1.25	1.55

TRACK SUPPLIES — Prices per 100 lb., f.o.b., for carload lots:

	Pittsburgh	Birmingham	Chicago
Angle bars	$2.55	$2.55	$2.75
Standard spikes	2.15	2.15	2.60
Tie plates	1.75	1.85	1.85
Track bolts	3.50	3.50	3.50

Pipe

WROUGHT STEEL PIPE — Discounts from standard list for delivery from warehouse, except at Pittsburgh, where prices are f.o.b. mill. List prices per ft. as follows: 1-in., 17c.; 3-in., 76½c.; 3½-in., 92c.; 6-in., $1.92.

	1 to 3-In. Butt Weld		2½ to 6-In. Lap Weld	
	Black	Galvanized	Black	Galvanized
Atlanta	52%	44.5%	50%	42%
Chicago	57.25%	44.71%	53.83%	41.29%
Cleveland	53.3%	42.3%	50.8%	37.8%
New York	56.14%	43.6%	52.72%	40.18%
Philadelphia	57.28%	44.68%	53.68%	41.80%
Pittsburgh	71%	62%	69½%	60½%
St. Louis	60.%	50%	58%	48%

Current Prices of Construction Materials

Pipe—Continued

CAST-IRON PIPE — Prices per net ton, for bell and spigot pipe, Class B and heavier, f.o.b. in carload lots; gas pipe and Class A, $3.00 per ton extra:

	4-In.	6-In. and Over
Atlanta	$39.50	$36.50
Boston	44.00	41.00
Birmingham (Base)	35.00	32.00
Burlington (Base)	38.00	35.00
Chicago	43.50	40.50
Dallas	47.50	44.50
Los Angeles	43.50	40.50
New York	41.50	38.50
Philadelphia (rail delivery)	39.50	36.50
Pittsburgh	44.50	41.50
St. Louis	42.50	39.50
San Francisco	43.50	40.50

SEWER PIPE—Prices delivered, per foot, for standard pipe; 6, 8 and 12-in. are single strength and 18, 24, 30 and 36-in. are double strength:

	6-In.	8-In.	12-In.	18-In.	24-In.	30-In.	36-In.
Atlanta	$0.135	$0.21	$0.385	.....	$1.40	.....	.....
Baltimore	.10	.30	.58	.....	1.93	.....	$6.50
Birmingham	.18	.30	.54	$1.02	1.95	$3.50	5.00
Boston	.135	.21	.405	1.325	2.385	4.68	7.175
Chicago	.18	.28	.54	1.25	2.25	4.75	6.00
Cincinnati	.0945	.....	.2835	.....	1.125	2.448	.....
Cleveland	.1575	.245	.4725	1.25	2.25	3.96	6.15
Dallas	.236	.....	.7165	.....	2.70	.....	.....
Denver	.16	.23	.414	.816	1.44	.....	.....
Detroit	.16	.25	.45	1.125	2.025	3.80	.....
Kansas City	.21	.335	.52	1.00	1.90	3.80	.....
Los Angeles(f.o.b.)	.2175	.2825	.5085	1.1865	2.034	3.69	.....
Minneapolis	.15	.21	.415	.95	1.72	2.85	3.75
Montreal	.30	.45	.75	1.95	2.60	.....	7.20
New Orleans	.16	.....	.51	.....	1.90	.....	.....
New York	.1665	.259	.4995	1.325	2.385	.....	.....
Philadelphia	.081	.126	.243	.65	1.17	2.376	4.615
Pittsburgh	.09	.18	.27	.62	1.22	2.45	3.68
St. Louis	.09	.205	.369	.945	1.62	3.20	4.40
San Francisco	.175	.25	.45	1.05	1.80	3.00	4.50
Seattle	.175	.275	.54	1.20	2.00	3.00	5.50

CLAY DRAIN TILE—Per 1,000 lin.ft., f.o.b., in carload lots, 4 in.:

Atlanta	$50.00	Los Angeles	$60.00
Birmingham	50.00	New Orleans	40.00
Boston	50.00	New York	35.00
Chicago	40.00	Philadelphia	36.00
Dallas	65.00	Pittsburgh	80.00
Denver	75.00	St. Louis	40.00
Detroit	60.00	San Francisco	67.50
Kansas City	60.00	Seattle	45.00

Miscellaneous

LINSEED OIL—Raw, in 5-bbl. lots, per lb., f.o.b.:

Atlanta (per gal.)	$0.80	Minneapolis	$0.113
Birmingham	.066	Montreal (per gal.)	.49
Boston (per gal. delivered)	.65	New York	.105
Dallas (per gal.)	.6375	Philadelphia	.075
Denver	.11	Seattle (per gal.)	.69
Kansas City (per gal.)	.80	St. Louis	11.5
Los Angeles	.0775	San Francisco (del)	.112

WHITE LEAD—In oil, per 100 lb. keg., f.o.b.:

Atlanta	$12.50	Montreal	$ 9.54
Birmingham	12.50	New Orleans	11.00
Boston	11.00	New York	11.00
Dallas	12.00	Philadelphia	9.90
Kansas City	11.25	Seattle	11.50
Los Angeles	10.25	St. Louis	11.00

CHEMICALS—Water, sewage treatment, road work, f.o.b., carlots, New York:

Bleaching powder, in drums, f.o.b. works, per 100 lb.	$1.75@2.00
Calcium chloride, 77-80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, f.o.b. works, freight equalized with points of competion, per ton	19.50
Chlorine, cylinders, per lb. delivered	.05½
Silicate of soda, in drums, f.o.b. works, per 100 lb.	1.65
Soda ash, 58%, in bags, per 100 lb.	1.22½
Sulphate of aluminum, in 200 lb. bags, per ton	23.50
Sulphate of copper, in bbl., per 100 lb.	3.50

MANILA ROPE—The number of feet per pound for the various sizes is as follows: ¼-in., 6-ft.; ½-in., 4-ft., 5-in.; ¾-in., 3-ft., 8-in.; 1-in., 2-ft., 5-in.; 1¼-in., 1-ft., 8-in. Following prices are per lb. for ¼-in. and larger, delivered in 1,200 ft. coils:

Atlanta	$0.18	Kansas City	$0.22
Baltimore	.225	Los Angeles	.155
Birmingham	.20	Minneapolis (f.o.b.)	.155
Boston	.13	Montreal	.14
Chicago	.175	New Orleans	.165
Cincinnati (f.o.b.)	.21	New York	.155
Cleveland	.20	Philadelphia	.15
Dallas	.18	St. Louis	.145
Denver	.165	San Francisco	.145
Detroit	.195	Seattle	.155

BUILDING PAPER—Black, 50-lb. per roll of 500 sq.ft., in carloads, f.o.b., producing point $2.30

SLATERS FELT—In carloads, per roll, f.o.b., producing point $0.65

PREPARED ROOFING—Per square, f.o.b., in carload lots:

	Single Shingles*	Strip Shingles†	Rolls‡
Atlanta	$5.00	$5.35	$1.75
Boston	5.76	3.18	1.41
Dallas	4.50	3.75	1.75
Detroit	6.25	6.50	1.85
Montreal	6.40	6.20	2.68
New Orleans	5.50	5.40	1.95
New York	6.50	6.25	2.50
Philadelphia	4.40	4.20	1.65
Seattle	8.75	5.50	2.25
St. Louis	6.40	5.22	1.49

*Slate finish, sufficient to cover 100 sq.ft. ‡Slate surfaced, in rolls weighing 85 to 90 lb. †4 in 1, hexagonal shape, with Underwriters' label.

ROOFING MATERIALS—In carload lots, f.o.b.:

	Asphalt Felt, per 100 Lb.	Tar Felt, per 100 Lb.	Asphalt Coating, per Gal.	Tar Pitch,* per Ton
Atlanta	$44.50†	$44.50†	$0.45	$22.50
Boston	2.40	2.40	.50	23.00
Dallas	2.75	2.75	.65	34.00
Montreal	2.62‡	2.02‡	1.40	1.63**
New Orleans	.....	2.50	.....	22.50
New York	2.40	2.40	.34‡	28.00
Philadelphia	2.25	2.25	.33	20.00
Seattle	2.40	2.40	.55	27.90
St. Louis	2.52	.....	.28	26.00

*In 350 lb. barrels. †Per ton. ‡Per roll. **Per English cwt.

WINDOW GLASS—Discounts from latest jobbers list, dated Sept. 15, 1928 for sizes above first three brackets:

	Single Thickness A Quality	Single Thickness B Quality	Double Thickness A Quality	Double Thickness B Quality
Atlanta	85%	85%	85%	85%
Birmingham	89%	91%	89%	91%
Boston	88%	90%	87%	89%
Dallas	85%	85%	85%	85%
Denver	84@5%	86@5%	84@5%	86@5%
Kansas City	89@10%	89@10%	89@10%	89@10%
New York	87%	89%	87%	89%
Philadelphia	88%	90%	88%	90%
Pittsburgh	87%	89%	87%	89%
Seattle	90@10%	90@20%	90@10%	90@20%

EXPLOSIVES—Price per pound for dynamite delivered:

	Gelatin 40%	Gelatin 60%		Gelatin 40%	Gelatin 60%
Atlanta	$0.215	$0.2375	Los Angeles†	$0.1725	$0.1925
Baltimore	.21	.225	Minneapolis	.1725	.1875
Birmingham	.13	.1525	Montreal	.1675	.1925
Boston	.245	.27	New Orleans	.19	.22
Chicago	.17	.195	New York	.245	.2675
Cincinnati (f.o.b.)	.22	.245	Philadelphia	.215	.24
Dallas	.2125	.2475	St. Louis	.1375	.1525
Denver	.19*	.205*	San Francisco	.1575	.1725
Kansas City, Mo.	.2025	.2225	Seattle	.1525	.175

*F.o.b Louviers. †F.o.b. arsenal.

Lumber

LUMBER—Per M. ft., b.m., No. 1, Common, rough, in carload lots:

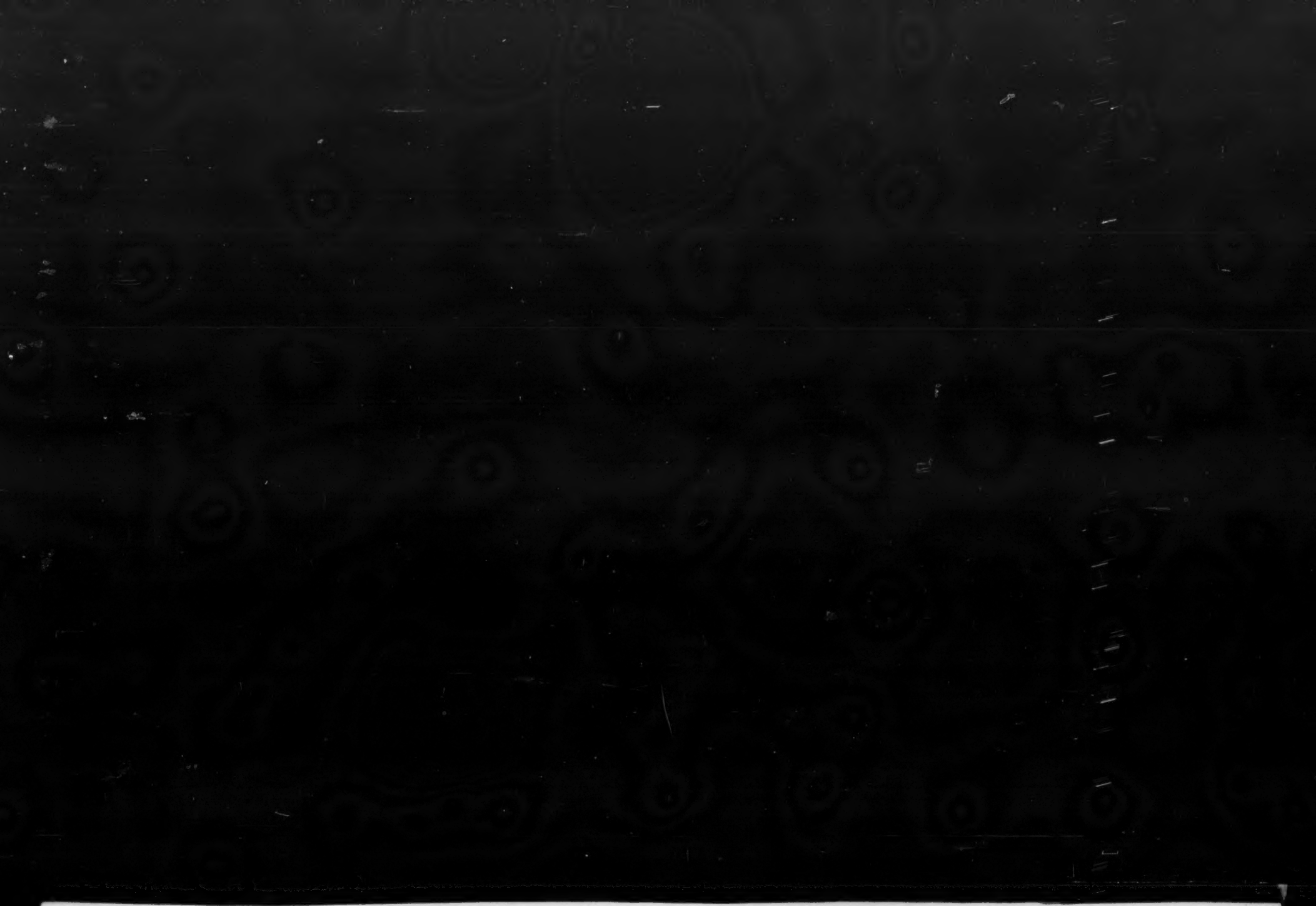
SOUTHERN YELLOW PINE

	1 x 6 In.* F.o.b.	1 x 6 In.* Del.	1 x 8 In.* F.o.b.	1 x 8 In.* Del.	3 x 12 In.† F.o.b.	3 x 12 In.† Del.	12 x 12 In.† F.o.b
Atlanta	$20.00	.....	$20.00	.....	$42.00	.....	$42.00
Baltimore	.....	$46.00	.....	$43.00	.....	$42.00	.....
Birmingham	18.00	20.00	18.00	20.00	20.00	22.00	30.00
Boston	25.00	30.00	26.00	31.00	59.00	64.00	59.00
Chicago	.....	.....	.....	.....	.....	62.50	.....
Cincinnati	.....	28.00	.....	28.00	.....	35.00	35.00
Cleveland	.....	21.00	.....	22.00	.....	28.00	30.00
Dallas	.....	35.00	.....	35.00	.....	50.00	52.50
Denver	.....	27.00	.....	27.00	.....	.....	.....
Detroit	30.00	32.00	30.00	32.00	32.00	32.00	45.00
Kansas City	.....	32.00	.....	35.00	.....	47.50	47.50
Minneapolis	.....	36.00	.....	36.00	.....	41.00	.....
Montreal	44.00	.....	45.00	.....	30.00	.....	.....
New Orleans	.....	18.00	.....	19.00	.....	30.00	.....
New York	22.00	24.00	23.00	25.00	50.00	52.50	50.00
Phil. No. 2(com.)	26.00	32.00	27.00	33.00	34.00	38.00	54.00
Pittsburgh	30.00	38.00	30.00	38.00	34.00	44.00	54.00
St. Louis	29.00	34.00	30.00	35.00	48.50	53.50	47.00

DOUGLAS FIR

	1 x 6 In.* F.o.b.	1 x 6 In.* Del.	1 x 8 In.* F.o.b.	1 x 8 In.* Del.	3 x 12 In.† F.o.b.	3 x 12 In.† Del.	12 x 12 In.† F.o.b
Baltimore	.....	$48.00	.....	$43.00	.....	$46.00	.....
Boston	$22.00	27.00	$22.00	27.00	$32.00	37.00	$37.00
Chicago	.....	.....	.....	.....	.....	44.52	.....
Cincinnati	.....	.....	.....	.....	.....	42.50	42.50
Cleveland	.....	23.50	.....	24.50	.....	31.00	32.00
Denver	.....	27.00	.....	27.00	.....	48.00	53.00
Detroit	.....	.....	.....	.....	30.00	30.00	45.00
Kansas City	.....	29.00	.....	32.00	.....	36.00	46.00
Los Angeles	19.00	20.50	19.00	20.50	21.00	22.50	21.00
Minneapolis	.....	36.00	.....	36.50	.....	43.00	.....
New Orleans	.....	21.00	.....	21.00	.....	42.50	.....
New York	19.00	21.50	20.00	22.00	22.50	24.50	24.00
Philadelphia	.....	.....	.....	.....	.....	34.00	38.00
Pittsburgh	.....	.....	.....	.....	46.00	58.00	47.00
St. Louis	34.00	39.00	34.00	39.00	35.00	40.00	35.00
San Francisco	.....	17.00	.....	18.00	.....	19.00	19.00
Seattle	14.50	15.50	14.50	15.50	16.50	17.50	17.50

*Form lumber, 16 ft. lengths. †Planks and timbers, 20 ft. lengths.

PILES—Prices of Nichols Bros., 90 West St., N.Y.C., per linear foot, pine, with bark on, f.o.b., New York; delivered from barge, 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.09	$0.145
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.13	.195
12 in.—2 ft. from butt	6 in.	60 to 69 ft.	.15	.215
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.185	.225
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.2025	.225
14 in.—2 ft. from butt	5 in.	80 to 85 ft.	.265	.375
14 in.—2 ft. from butt	5 in.	85 to 89 ft.	.305	.442